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NEPS IN CARD WEB AS RELATED TO SIX ELEMENTS OF RAW COTTON QUALITY //

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NEPS IN CARD WEB AS RELATED TO SIX ELEMENTS OF RAW COTTON QUALITY

By Robert W. Webb and Howard B. Richardson, cotton technologists

SUMMARY AND CONCLUSIONS

This is the eleventh in a series of reports concerning the relationships of cotton fiber properties to performance in manufacturing and quality of manufactured product.

The study reported is based on 828 lots of American upland cotton obtained from the test series for selected cotton improvement groups and the Experiment Station Annual Variety Series, crop years 1945-47. Most of the cottons represented the leading varieties in commercial production in the rainfall and irrigated parts of the American Cotton Belt during that period.

All cottons used in this study were processed through the picker and card by the same standard procedure and with the same settings and speeds.

The dependent variable used in these statistical analyses was the number of neps per 100 square inches of processed card web, as identified in all cases with delivery of a standard weight card sliver of 40 grains per yard, $9\frac{1}{2}$ pounds per hour, from a 40-inch card.

Six independent variables were included in these analyses: Upper half mean length (fibrograph), length uniformity ratio, fiber fineness (weight per inch), fiber bundle strength (Pressley), percentage of mature fibers, and grade index of cotton.

Measurements of these raw cottons and nep count in card web were stratified by crop year, series, variety, staple length, and combination of staple lengths. Data for each of these groups of cotton and card web, as well as for the over-all series, were studied by use of multiple and simple correlation analyses. A total of 182 correlation analyses was made.

A series of statistical values is reported for the relationships involved in the entire group of 828 cottons and in each of the 25 subgroupings of cottons studied. These values vary considerably, as naturally might be expected.

For the over-all series of cottons, the degree of relationship between the number of neps per 100 square inches of card web and the six elements of cotton quality included is not what generally is considered high, - the coefficient of multiple correlation (\bar{R}) being 0.541. The \bar{R} values, however, range from 0.739 to 0.398 for the various groupings of cotton studied.

In round numbers, the amount of variance in number of neps per 100 square inches of card web explainable on the basis of the six factors of cotton quality considered is 29 percent for the entire series of cottons and it ranges from 55 percent to 16 percent for the different groups of cotton analyzed.

The standard error of estimate (\bar{S}) for number of neps per 100 square inches of card web, as based on six elements of cotton quality, is + 9.5 for the over-all series of cottons. Such \bar{S} values, however, extend from ± 3.4 to ± 14.6 for all the subgroups of cotton considered.

One over-all equation is given for estimating the number of neps per 100 square inches of card web on the basis of six elements of raw cotton quality. (See page 19). An illustration of the basic calculations necessary for using the equation is shown.

Actual number of neps per 100 square inches of card web would be expected to occur in two-thirds of the cases within + 9.5 of the estimated number, when the equation based on the six elements of cotton quality is used.

The over-all precision of estimate of nep count in card web on the basis of the six factors considered is not very high, considering the fact that the mean number of neps per 100 square inches of card web was 16.5 for the 828 cottons. The nep count per cotton, however, ranged from 173 to 1 and the standard deviation of nep count was ± 11.3 for the entire series of cottons.

Of the five varietal groupings of cotton studied, the highest degree of correlation between the six factors of cotton quality and nep count of card web occurs with the samples of Coker 100 cotton; the least, with the lots of Acala 1517 type of cotton. The other three varieties are intermediate in this respect, ranking in order as follows: Stoneville 2B, Deltapine 14, and Rowden.

The extent of variance in number of neps per 100 square inches of card web explainable by the six factors of cotton quality varies with the different varietal groupings of cotton, as follows: Coker 100, 29 percent; Stoneville 2B, 27 percent; Deltapine 14, 24 percent; Rowden, 19 percent; and Acala 1517 type, 16 percent.

The precision of estimate for number of neps per 100 square inches of card web, as based on the six elements of cotton quality, also varies with the varietal groupings of cotton. The best was obtained with the Rowden cottons and the poorest, with the Acala 1517 type of cotton. They furnished standard error values (\bar{S}) of ± 3.6 and ± 9.3 , respectively.

In general, the longer the cotton, the lower the grade, the finer the fibers, the smaller the percentage of mature fibers, and the less uniform the fiber lengths, the larger was the number of neps per 100 square inches of card web.

Fiber strength caused a statistically significant effect on nep count in card web with some of the groups of cotton studied. The direction of the effect of this fiber property on nep count, however, was not consistent nor that generally thought to exist. That is, in 3 out of the 4 statistically significant cases, the stronger the fibers the larger was the number of neps per 100 square inches of card web. In the fourth case, the weaker the fibers the larger was the nep count. No positive explanation can be given at the present time for the disparity in these findings but some considerations are suggested.

When the contribution of a fiber property to the number of neps per 100 square inches of card web is comparatively small or statistically insignificant, its evaluated influence may be found to be either positive or negative. Inconsistencies of this type, however, are understandable and seemingly reflect no particular significance.

Upper half mean length, grade index, fiber strength, percentage of mature fibers, and length uniformity ratio were the order of rank of net importance for the five variables making a statistically significant contribution to number of neps per 100 square inches of card web, when all 828 samples were considered collectively. Although the net effect of fiber fineness was statistically insignificant in this case, fiber fineness ranked fourth among the six fiber properties considered.

The ranks of net importance of the six elements of cotton quality to nep count in card web fluctuated with some of the subgroupings of cottons studied. For certain of the groups of samples, none of the quality factors were found to cause a statistically significant effect. The latter occurred more frequently with the staple-length and varietal groupings. Generally, however, one, two, three, or four of the cotton-quality factors produced a statistically significant effect on nep count in card web in each case.

It is probable that the factors of fiber maturity and uniformity of fiber length influence per se the number of neps per 100 square inches of card web to a greater extent than the reported findings for the measures used in this study for those elements. Limitations in the measures used are explained.

Generally, with the various groupings of samples, a larger number of cotton quality elements produced a gross effect on number of neps per 100 square inches of card web that was statistically significant, as compared with net effect. This is understandable by reason of the fact that the gross effects, as determined by simple correlation analysis, disregard the interrelationships between the fiber properties, whereas the net effects, as determined by the beta coefficients from multiple correlation analysis, take into account those interrelationships.

Improvement in the statistical values presented in this report cannot be expected from curvilinear analyses, as application of such technique to the data failed to reveal any evidence of curvilinear relationships being involved.

Pertinent findings from selected publications by other authors are assembled and discussed in this report. This partial review of the literature concerns neppiness in cotton as related more particularly to fiber immaturity, as well as to other fiber properties, certain varieties and strains of cotton, location and season of growth, textile processing, yarn properties, and fabric quality.

INTRODUCTION

In this series of relationship studies, 10 previous reports and 1 address have been published to date, as follows: (31),^{1/} (32), (33), (34), (35), (36), (37), (38), (39), (40), and (41). These have dealt with yarn strength and appearance, tire cord strength and elongation, and manufacturing waste as dependent variables. Both carded and combed yarns have been included, as well as regular-draft and long-draft processed yarns. This is the first report of the series bearing on the relationships with respect to neps.

Neps, those small tangled knots of cotton fibers, are objectionable imperfections in ginned lint, cotton yarns, and fabrics, and they occur to a greater or less extent in all commercial cottons. Cottons, however, vary greatly in their tendency toward the formation of neps during ginning and textile processing. The occurrence of neps in appreciable numbers detracts from the appearance of yarns and fabrics in the gray state, and even more when such products are dyed or printed. The latter condition is caused by the fact that neps generally absorb dyes to a different extent from that of their background material and accordingly they appear as spots.

A very desirable feature of any cotton is its relative freedom from neps and its resistance to the formation of neps during the ginning and manufacturing processes. When the nep count in the card web is high, the cotton is likely to produce rough and neppy yarns. Excessive neppiness, therefore, influences and limits the uses for which a cotton is suitable. It is the concensus of opinion among mill men, as confirmed by laboratory testing, that highly neppy cottons exhibit poor running qualities during conversion of the raw stock into yarns, - generally giving up more manufacturing waste and showing more ends down in spinning than do less neppy cottons. A high degree of neppiness thus increases the per-unit cost of cotton manufacture.

^{1/} Underscored numbers in parenthesis refer to Literature Cited, p. 36.

Using the same six elements of cotton quality as were used in the preceding studies, similar sets of multiple and simple correlation analyses have been made in which the number of neps for 100 square inches of card web served as the dependent variable. The latter measure was purposely chosen because it represents the point in cotton textile processing where nep content determinations can be made most conveniently. The groupings of samples and the method of statistical analysis used in this study are the same as those used in the three previous studies reported in this series, (39), (40), and (41), and the groupings are with the same 828 cottons from the 1945-47 crop years.

No comprehensive survey of the literature has been attempted in this instance. References to published studies and results bearing more directly on the findings and discussion presented in this report, however, have been included. Some publications cited contain extensive bibliographies for earlier and basic investigations on the nep problem.

The most extensive single review of literature available on the subject of neps is the one recently published by Bogdan (5). A total of 95 published articles are referred to in his survey. There are, however, several contributions of interest in this connection, which are not included in Bogdan's review, namely, Abdelhafez (1), Bogdan (4), Gulati (8), (9), Lord (11), Loveless (12), and Pearson (16).

SAMPLES, TESTS, AND DATA

The samples of cotton used in this study were obtained from the Experiment Station Annual Variety Test Series for the three crop years of 1945-47 and from the test series for selected cotton-improvement groups for the two crop years of 1946-47. They were grown in connection with the Federal-State cotton improvement programs. 2/

2/ Selection of varieties for the Experiment Station Annual Variety Test Series, as well as the production and ginning of those samples, were carried out by the Bureau of Plant Industry, Soils, and Agricultural Engineering, in cooperation with State agricultural experiment stations and substations.

Selection of the cotton-improvement groups was made by the Cotton Branch of the Production and Marketing Administration, with the assistance of Federal and State cotton breeders and improvement specialists, and private cotton breeders. Samples were collected and selected by the field classification offices of the Cotton Branch, in connection with its classification service for organized cotton-improvement groups, as provided under the Smith-Doxey Act.

Fiber and spinning tests were conducted in the laboratories operated cooperatively by the Cotton Branch, Production and Marketing Administration, and the Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA, and the Agricultural and Mechanical College of Texas, and the Clemson Agricultural College of South Carolina.

Source Of Data

All fiber and nep-count data used in the analyses reported herein resulted from tests made in the laboratories of the Cotton Branch of the Production and Marketing Administration. The basic data are those which were reported by that agency in eight publications, as follows: (20), (21), (22), (23), (24), (25), (27), (28). No report was issued by PMA covering results for the complete Experiment Station Annual Variety Test Series, Crop Year 1946. Data representing the samples grown in South Carolina and in Texas during 1946, however, were reported separately in two of the publications cited above; namely, (22) and (23). Unpublished data in the files of the Cotton Branch were used for the samples grown in other States for the crop year of 1946. For the 1947 crop, data from the Experiment Station series were used only for the cottons grown in South Carolina and Texas, as reported by PMA in publications (27) and (28).

For those who may be interested in the fiber and spinning data for the complete Experiment Station Annual Variety Test Series, Crop Years 1946 and 1947, reference may be had to two reports (26) and (29), as published by the cooperating Bureau of Plant Industry, Soils, and Agricultural Engineering. The fiber data listed in those publications, however, resulted from tests conducted by that Bureau. None of its fiber data have been used in the analyses reported herein.

Cottons

All the cottons were of the American upland type; they represented not only the leading varieties in commercial production during those years in the rainfall and irrigated parts of the American Cotton Belt but also included some special cottons not in commercial production. The Experiment Station Annual Variety Test Series of cottons was grown at various Federal and State experiment stations and substations and the test series for the selected cotton-improvement groups was grown commercially within their general area of growth adaptation. The ranges of growth conditions, fiber properties, and yarn strength identified with a particular variety in the Experiment Station Series, however, may be somewhat wider than those usually found in commercial production of the same variety.

Sampling

One sample of cotton was collected in the customary manner, for each variety grown at each location during each crop year, in connection with the Experiment Station Test Series. Samples weighing 8 to 10 pounds were taken at the peak of production for the respective varieties; thus, they represented early season or first picking. Classing samples weighing 4 to 6 ounces were assembled for the most frequently occurring grade and staple-length groups of each selected cotton-improvement area, after

eliminating the first 5 percent of samples in the various categories, until 8 to 10 pounds of raw cotton had been accumulated. In 1946, the samples from the selected cotton-improvement groups represented only first picking, or early season cottons; in 1947, they represented both first and second pickings, or early and midseason cottons.

Processing of Cottons

All the cottons used in this study were processed through the picker and card by the same standard procedure and with the same set of settings and speeds. Details concerning the manufacturing organization, settings, and speeds used at the spinning laboratories in processing these samples through the picker and card are shown in table 1 of the Appendix.

Neps in Card Web

The dependent variable used in all these statistical analyses was the number of neps per 100 square inches of processed card web, as identified with the delivery of a standard weight card sliver of 40 grains per yard from a 40-inch card. Visual observations and evaluations of neps in the card web were made on all samples by the standard procedure used in the spinning laboratories for a number of years.

Five 36-square-inch samples, totaling 180 square inches of card web, were used as a basis for the nep test on each lot of cotton. These samples were taken at approximately equal intervals during the processing of each lot of cotton in an effort to obtain representative samples. To extract each sample, a 4-inch by 9-inch board, covered with black velvet, was lifted from under the card web while the card was running, thus causing the web to cover the face of the board. Excess web hanging over the edge of the board was cut with scissors, whereby a 4-inch by 9-inch sample remained to be checked for neps. This sampling operation was handled carefully to prevent stretching of the sample and unnecessary damage to the web. The neps in each of the samples were counted by two experienced technicians with no visual aid except a good light. From these counts, the number of neps per 100 square inches of card web was calculated by the following formula:

$$X = \frac{A + B}{2} \times \frac{100}{180}$$

X = number of neps per 100 square inches of card web.

A = total neps in the 5 boards as counted by technician A.

B = total neps in the 5 boards as counted by technician B.

Descriptive adjectives and number of neps per 100 square inches of card web are given in table 2 for cottons covering a relatively wide range of neppiness. This information will be helpful for a better understanding of this study and in evaluating the findings reported.

Fiber Properties

Six elements of raw cotton quality were included as six independent variables in the statistical analyses covering neps per 100 square inches of processed card web for each cotton, as follows:

Upper half mean length, as determined by the fibrograph.

Uniformity ratio, as determined by the fibrograph.

Fiber fineness, as determined in terms of weight per inch.

Fiber strength, as determined by the Pressley bundle method.

Percentage of mature fibers, as classified and counted after they had been permitted to swell in an 18 percent sodium hydroxide solution.

Grade of cotton, as expressed in terms of an index.

The tests relating to the data used in the analyses are those referred to in the Production and Marketing Administration publications cited and are described briefly in the report entitled "Cotton Testing Service" (30). The tests are considered more fully in the text and literature cited in the first and third reports in this series of relationship studies (32), (34).

Grade index was used in this study, as explained in an earlier report of this series (38). The conversion chart for obtaining grade-index values of samples of raw cotton corresponding to various grade designations, values of which should be used when applying the equation reported on page 19, is shown in table 3.

The original grade designations are those assigned to the various samples of raw cotton by U. S. cotton specialists in accordance with the Universal Standards for grade of American upland cotton, as described in "The Classification of Cotton," (19).

The staple-length designations, which served as the basis for stratifications of data in the analyses, are those assigned to the various samples of raw cotton by U. S. cotton specialists in accordance with official standards for staple length of American upland cotton, as defined in (19).

METHOD OF STATISTICAL ANALYSES

The same series of cottons and the same groupings of data have been used in the analyses covering the number of neps per 100 square inches of processed card web as was done in the three previous studies and reports for this series of cottons, namely, with yarn strength (39), with count-strength product (40), and with yarn appearance (41).

In this study, a total of 182 statistical analyses was made: 26 multiple correlation analyses for 6 fiber properties with nep count as the dependent variable and 156 simple correlation analyses for one fiber property at a time with the same dependent variable.

The same general pattern of statistical analysis was followed as in all of the previous studies of this series. For more detailed information as to the statistical terms, measures, and technique involved, see the Appendix and the literature citations in the first and third reports of this series (32), (34).

Beta coefficients were used for evaluating the relative importance of the fiber properties to number of neps per 100 square inches of card web instead of partial correlation coefficients (as was done in the early studies of this series), and a correction factor was applied to the respective statistical values obtained from all the analyses. The need of and advantages from using such procedures in connection with analyses of data by such subgroupings, representing variable numbers of samples, are set forth in (38).

No correlation analyses were made with nep count of card web and three fiber properties, as generally was done with other phases of the relationship problem covered in previous reports of this series. This was not done because of the fact that every one of the six fiber properties caused a relatively small contribution to the number of neps per 100 square inches of card web in the over-all series of cottons; that no outstanding importance in this respect was shown by any two or three of them; and that the one or two fiber properties, which did show noteworthy importance to nep count in the card web, varied in a number of cases with the various subgroupings of samples.

RELATION OF SIX FIBER PROPERTIES TO NUMBER OF NEPS IN CARD WEB

The degree of relationship found to exist between the six collective elements of cotton quality and number of neps per 100 square inches of card web is shown for the various groupings of cotton used in the respective analyses by the values listed for the multiple correlation coefficients (\bar{R}) in table 4 of the Appendix.

It may be noted that the coefficient of multiple correlation was 0.541 for the over-all series of 828 cottons. For the cottons stratified by year, variety, staple length, and combination of staple lengths, the correlation coefficients ranged from 0.739 for the Experiment Station Annual Variety Series of 1947 to 0.398 for the group of cottons classified as 1-1/16 inches in staple length.

Of the 5 varieties studied separately, the highest degree of correlation between the 6 fiber properties and number of neps per 100 square inches was shown by the Coker 100 (all strains) group of cottons with an \bar{R} value of 0.539; and the lowest by the Acala 1517 type of cotton with

an \bar{R} value 0.401. The latter finding is of more particular interest because of the fact that the mean number of neps per 100 square inches of card web was 24.8 for the group of cottons representing the Acala 1517 type, as contrasted with 9.5 for the Rowden variety (all strains) and with 17.2, 17.4, and 17.1 for the other respective varieties, namely, Coker 100 (all strains), Stoneville 2B, and Deltapine 14.

When the cottons were analyzed by individual staple lengths, the highest degree of correlation between the six fiber properties and number of neps per 100 square inches of card web was found with the 15/16-inch group of cottons, the \bar{R} value being 0.675, followed closely by that of 0.652 for the 31/32-inch group of cottons. The lowest degree of correlation between these variables was obtained with the cottons representing 1-1/16 inches and 1-1/32 inches in staple length, the respective \bar{R} values being 0.398 and 0.459. Although some fluctuations occurred in the results with the various staple-length groupings of cotton and although no outstanding or wholly consistent trend appeared in them, there was a tendency for the degree of correlation between the six fiber properties and number of neps per 100 square inches of card web to decrease with the increase in staple length of the cotton.

The correlation results obtained from the cottons, grouped by pairs of adjacent staple lengths, were in general line with those cited for the individual staple-length groupings.

EXTENT OF VARIANCE IN NUMBER OF NEPS IN CARD WEB EXPLAINED BY SIX FIBER PROPERTIES

The percentage of total variance in number of neps per 100 square inches of card web explainable by the six elements of cotton quality is shown, for the different groupings of cotton, by the values listed in table 4 for the coefficients of determination (\bar{R}^2) multiplied by 100.

For the over-all series of 828 cottons, 29.3 percent of the variance in the number of neps per 100 square inches of card web is explained by the 6 factors of cotton quality. The values, however, ranged from a high of 54.6 percent for the 1947 Annual Variety Series of cottons to a low of 15.8 percent for the group of cottons classified as 1-1/16 inches in staple length.

For the five respective varieties, the extent of variance in number of neps per 100 square inches of card web explainable by the six fiber properties ranged from 29.1 percent for Coker 100 (all strains) to 16.1 percent for the Acala 1517 type of cotton. The other three varieties were intermediate in this respect, the values extending from 26.9 percent to 19.1 percent.

In the case of the staple-length groupings, the extent of variance in number of neps per 100 square inches of card web accounted for by the six fiber properties was 35.6 percent for the 7/8-inch cottons and it fluctuated to 23.9 percent for the cottons of 1-3/32 inches in staple length. This is a difference of approximately 12 percent between the shortest and longest groups of cotton studied.

The largest extent of variance in nep count of card web explainable by the fiber properties in the staple length series was observed with 15/16-inch cottons (45.6 percent) and the least extent with the cottons of 1-1/16 inches (15.8 percent). This is a difference of approximately 30 percent.

The extent of variance in nep count of card web explainable by the six fiber properties is noticeably larger for the groups of cotton shorter than 1 inch in staple length than it is for the cottons longer than 1 inch. What the precise explanation is for this difference in level of such relationship findings is not known at present.

For the groupings of cotton by pairs of adjacent staple lengths, the variance in the number of neps per 100 square inches of card web explained by the six factors extended from 33.9 percent for the 7/8-inch and 29/32-inch cottons to 16.0 percent for the 1-1/16-inch and 1-3/32-inch cottons. The largest value, however, was 45.4 percent with the 15/16-inch and 31/32-inch cottons. The over-all range in values for this series, therefore, is nearly 30 percent.

PRECISION IN ESTIMATES OF NUMBER OF NEPS IN CARD WEB ON THE BASIS OF SIX FIBER PROPERTIES

The standard errors of nep-count estimate (\bar{S}), as obtained on the basis of the six elements of cotton quality considered, are shown in table 4. Values also are listed in this table for the mean number of neps per 100 square inches of card web, as well as the associated standard deviation, maximum, minimum, and range values actually observed for each group of samples. The standard error values indicate the range within which the actual number of neps per 100 square inches of card web would be expected to occur, in two-thirds of the cases, with respect to the estimate.

The standard error of estimate for number of neps per 100 square inches of card web is + 9.5 for the over-all series of 828 cottons, ranging from + 3.4 to + 14.6 with the various groupings studied. This is a difference of 11.2. On the basis of the mean number of neps per 100 square inches of card web for the respective groups of samples, the standard error of estimate for nep count in card web was calculated to be + 57.6 percent for the over-all series of cottons and ranged from + 21.8 percent to + 78.4 percent for the different groups of samples. This is a difference of 56.6 percent.

The precision of estimate for nep count in card web, on the average, was better for the cottons coming from the selected cotton improvement groups than from the Experiment Station Annual Variety series. The \bar{S} values for the three series of the former averaged + 5.5 as compared with + 9.3 for the latter. The mean number of neps occurring per 100 square inches of card web was approximately the same for all six groups of cottons, stratified by crop year and series. Variation in the number of neps in the individual cottons in the selected cotton improvement groups was relatively uniform, as shown by the comparatively small and consistent values of + 5.9, + 8.3, and + 7.4 for their respective standard deviations. The individual cottons representing the three Experiment Station Annual Variety series, however, were more variable in number of neps per 100 square inches of card web, as revealed by the larger and more inconsistent values of + 7.1, + 10.1, and + 21.5 for their respective standard deviations.

Of the varieties studied separately, the samples of Rowden cotton showed - by far - the smallest mean number of neps occurring per 100 square inches of card web (9.5) and the smallest standard error of estimate for nep count in card web (+ 3.6). Acala 1517 type of cotton furnished the largest mean number of neps per 100 square inches of card web (24.8), of the varieties analyzed individually, and the largest standard error of estimate with respect to such nep count (+ 9.3). The other three varieties, namely, Coker 100, Stoneville 2B, and Deltapine 14 were intermediate between these extremes, as regards both the mean number of neps actually occurring per 100 square inches of card web and the precision of estimate for neps in that unit area of card web.

As regards the variability in nep count of card web for the total number of samples of each variety studied separately, the Rowden variety was the most uniform, with a standard deviation of + 3.9, and Acala 1517 type of cotton was the most variable, with a standard deviation of + 10.0. The standard deviations of the other three varieties were intermediate and in close agreement.

What has been said previously for the varietal precision of estimate with respect to number of neps per 100 square inches of card web, as based on the six elements of raw cotton quality considered, was reported in terms of absolute standard errors of estimate (\bar{S}) for the respective varieties. However, when such absolute standard errors of estimate were converted to a percentage of the mean number of neps actually occurring per 100 square inches of card web for the respective varieties, the varietal manifestations in this respect assumed a somewhat different order. That is, on the basis of relative standard errors of estimate of nep count in card web, the most precise estimate (+ 33.5 percent) was obtained with the cottons representing the Deltapine 14 variety and the least precise (+ 43.1 percent) was obtained with the Stoneville 2B variety. The other three varieties showed approximately the same intermediate relative standard errors of estimate, the values being + 36.9 percent for all strains of the Coker 100 cotton tested, + 37.4 percent for the lots of Acala 1517 type of cotton included, and + 37.8 percent for all strains of the Rowden variety considered.

With respect to the groups of cotton studied by individual staple length from $7/8$ inch to $1-3/32$ inches and by combination of paired adjacent staple lengths over this range, the findings showed no outstanding trends with staple length as regards absolute and relative standard errors of estimate for nep count in card web, mean number of neps actually occurring per 100 square inches of card web, and standard deviation for the frequency in occurrence of neps in card web. An occasional tendency in certain of these respects was noted but these were too small and inconsistent to justify their being credited with any particular significance.

NET IMPORTANCE OF THE RESPECTIVE FIBER PROPERTIES TO NUMBER OF NEPS IN CARD WEB

The relative net effect of each of the six separate elements of cotton quality on the number of neps per 100 square inches of card web, together with their comparative ranks of importance to such, are shown by the beta coefficients, listed by series and crop year, in table 5; by variety, in table 6; by staple length, in table 7; and by combination of staple lengths, in table 8. As the tabulations are self-explanatory, only a few general comparisons and specific comments will be made.

It will be noted from table 5 that, for the entire series of 828 cottons, all the factors of raw-cotton quality considered made a statistically significant net contribution to the number of neps in card web, except fiber fineness (weight per inch). Their effects were comparatively small but upper half mean length ranked first in importance to nep count; grade index, second; and fiber strength, third. Percentage of mature fibers and length uniformity ratio barely produced statistically significant effects, ranking fifth and sixth in importance, respectively.

By series and crop year. For the various groups of cotton reported in table 5, each fiber property except fiber strength, ranked first in net importance to neps per 100 square inches of card web, at least once and sometimes twice.

By variety. For the varieties studied separately and reported in table 6, three fiber properties proved statistically significant to the number of neps per 100 square inches of card web in the case of the Coker 100 group of cottons. Ranked in order of their importance, they were fiber fineness, grade index, and percentage of mature fibers.

For the Deltapine 14 cottons, only grade index was statistically significant with respect to the number of neps in card web and it occupied the first rank of importance. The other five fiber properties proved definitely insignificant.

With the other three varieties, namely, Stoneville 2B, Rowden, and Acala 1517, none of the six fiber properties caused a statistically significant net effect on the number of neps occurring per 100 square inches of card web. Although some of the beta coefficients were relatively large, their associated standard errors were so large as to make the beta values statistically insignificant in that they were less than three times their respective standard errors.

By staple length. When the cottons were studied by eight individual staple-length designations, the results of which are shown in table 7, only three groups showed as much as one fiber property to be statistically significant to the number of neps in the card web. Length uniformity ratio ranked first in importance to nep count in the case of the 7/8-inch cottons, and fiber weight fineness stood first for the two groups of cottons classified as 1-1/32 inches and 1-1/16 inches, respectively.

By combination of staple lengths. Analyses made on the cottons grouped by two or three adjacent staple-length designations generally showed more fiber properties to possess statistical significance with respect to the number of neps per 100 square inches of card web than was the case with the individual staple-length groupings. According to the results reported in table 8, the following is the rank of net importance of the statistically significant fiber properties to nep count in card web:

7/8-inch and 29/32-inch cottons	- Length uniformity ratio.
15/16-inch and 31/32-inch cottons	- Maturity, grade index.
1-inch and 1-1/32-inch cottons	- Fiber weight fineness, grade index.
1-1/16-inch and 1-3/32-inch cottons	- Fiber weight fineness.
31/32, 1, and 1-1/32-inch cottons	- Fiber weight fineness, grade index.

The findings reported above and in table 8 for combinations of staple length probably possess more significance to nep count in card web, from the standpoint of raw stock used in practical processing in commercial textile mills, than do those cited previously in the text and in table 7 for individual staple lengths. It is common knowledge, for example, that the mixes of cotton used in most mills generally include two or more adjacent staple lengths in various proportions; even when a blend is selected to represent only one staple-length designation, the best of cotton classing permits a staple-length range of the order used in these analyses.

General. By way of summary of the findings from the 26 analyses of as many groups of cotton and from those cases in which the fiber property had a statistically significant effect on the number of neps per 100 square inches of card web, the various fiber properties, ranked in order of relative net importance, are as follows:

Upper half mean length:	First in 1 case, second in 1 case.
Grade index:	First in 2 cases, second in 6 cases, and third in 1 case.
Fiber strength:	Second in 1 case, third in 2 cases, and fourth in 1 case.
Fiber fineness:	First in 8 cases and second in 1 case.
Percentage of mature fibers:	First in 3 cases, third in 1 case, fourth in 1 case, and fifth in 1 case.
Length uniformity ratio:	First in 3 cases, third in 1 case, and sixth in 1 case.

It is believed that percentage of mature fibers and length uniformity ratio, as fiber properties per se, actually have more effect on the number of neps per 100 square inches of card web than the reported findings from this study would indicate. The basis for the position expressed is explained in the chapter entitled "Some Considerations for Possible Improvement in Evaluations of Nep Relationships."

GROSS IMPORTANCE OF THE RESPECTIVE FIBER PROPERTIES TO NUMBER OF NEPS IN CARD WEB

The relative gross effects of the six separate elements of cotton quality on the number of neps per 100 square inches of card web, together with their comparative ranks of importance to those dependent variables, are shown by the \bar{r} and \bar{r}^2 values listed by series and year in table 9, by variety in table 10, by staple length in table 11, and by combination of staple lengths in table 12.

All the values shown in tables 9 to 12 were obtained from simple correlation analyses; that is, when only one element of cotton quality at a time is correlated with neps in card web. The coefficients of simple correlation, therefore, disregard the interrelationships occurring between the fiber properties, whereas the beta coefficients take them into account. These findings relating to relative gross importance are of interest in connection with the respective beta coefficients previously reported for the net importance of these fiber properties on nep count in card web.

For the entire series of 828 cottons, as shown in table 9, all six elements of raw cotton quality made a statistically significant gross contribution to the number of neps in card web. Their rank of importance were fiber fineness, upper half mean length, uniformity ratio, percentage of mature fibers, grade index, and fiber strength.

By series and crop year. For the various cottons analyzed by the groupings reported in table 9, the fiber properties varied in their gross importance to the number of neps per 100 square inches of card web. All the factors studied, except upper half mean length and fiber strength, ranked first in importance one or more times.

By variety. The results obtained from simple correlation analyses for the five varieties analyzed separately are shown in table 10. For two of the varieties, three fiber properties made a statistically significant gross contribution to the number of neps per 100 square inches of card web. For the Stoneville 2B cottons, percentage of mature fibers, fiber fineness, and grade were the order of rank. For the Deltapine 14, they were grade index, percentage of mature fibers, and fiber fineness.

For two of the varieties, only one fiber property was found to make a statistically significant gross contribution to nep count in card web. This fiber property was grade index for the Coker 100 cottons and fiber fineness for the Rowden cottons.

For the Acala 1517 cotton, none of the six fiber properties caused a statistically significant gross effect on nep count in card web.

By staple length. Results from simple correlation analyses on the cottons representing eight staple length groupings are shown in table 11. For two of the groups, only one fiber property showed a statistically significant gross effect on the number of neps per 100 square inches of card web, namely, length uniformity ratio with the 7/8-inch cottons and fiber fineness with the 1-1/32-inch cotton. In the case of 1-3/32-inch cottons, two fiber properties appeared significant in this respect, the order of rank being fiber fineness and fiber strength.

For each of the other five groups of samples (29/32 inch, 15/16 inch, 31/32 inch, 1 inch, and 1-1/16 inches), three fiber properties showed a significant effect in this connection. Although the order of rank fluctuated somewhat for these groups of cotton, the three most important fiber properties generally were fiber fineness, length uniformity ratio, and percentage of mature fibers. However, with two of the staple-length groupings (1 inch, 1-1/16 inches), grade index occurred among the three most important fiber properties.

In this connection, it is of interest to note that length uniformity ratio was the first factor of gross importance to nep count in card web for four of the five shortest length groupings of cotton, namely, 7/8 inch, 29/32 inch, 15/16 inch, and 1 inch. Fiber fineness, on the other hand, was the most important property for the three longest groups, namely, 1-1/32 inches, 1-1/16 inches, and 1-3/32 inches.

By combination of staple lengths. Results obtained from simple correlation analyses for the five combinations of adjacent staple-length groupings of cotton, are listed in table 12. The findings follow more or less in line with those reported previously for the individual staple length groupings of samples. Grade index, however, proved to be a factor of greater importance to nep count in card web for the groupings of cottons by combination of staple lengths than by separate staple lengths.

A larger number of statistically significant cases generally occurred per length group of cotton with the six factors in relation to nep count in card web on the basis of gross effects than on the basis of net effects. The averages were computed to be 2.4 and 3.8, respectively.

General. The gross effects on neps per 100 square inches of card web reported for the six elements of cotton quality are what might be expected, on the basis of the net effects indicated for them by the beta coefficients previously shown, and that the coefficients of simple correlation disregard the interrelationships occurring between the fiber properties, whereas the beta coefficients take them into account.

As stated in the previous chapter, it is possible that the percentage of mature fibers and the length uniformity ratio, as fiber properties per se, probably have more effect on number of neps per 100 square inches of card web than the reported results from this study would indicate. This subject is considered further in the chapter entitled "Some Considerations for Possible Improvement in Evaluations of Nep Relationships."

DIRECTION OF CONTRIBUTION OF THE RESPECTIVE FIBER PROPERTIES TO NUMBER OF NEPS IN CARD WEB

A comparison of the signs attached to the beta coefficients obtained for the various analyses, by various groupings of cotton, is of interest. This summary is based on the values and signs listed in tables 5, 6, 7, and 8.

Upper half mean length. Of the total 26 cases, 13 of the beta coefficients possessed a positive sign and 13, a negative one. Only two of the beta coefficients, however, were statistically significant. Both of these carried a positive sign, meaning that the longer the cotton the larger was the number of neps per 100 square inches of card web, and vice versa.

The beta coefficients for upper half mean length in relation to nep count in card web were statistically insignificant in 24 cases. A plus sign was attached to 11 of these and a negative sign to 13. However, as the values of the beta coefficients concerned are statistically insignificant on the basis of their respective standard errors, it seems reasonable to conclude that such variation in their signs also is without any particular significance or meaning.

Grade index. All 26 beta coefficients pertaining to this factor possessed a negative sign, meaning that the higher the grade the smaller was the nep count in card web, and vice versa. This finding, supported by such consistent evidence, is of considerable practical significance to the universal grade standards for cotton, as prepared by the U. S. Department of Agriculture and against which the samples of this study were classified.

The beta coefficients for grade index in this connection were statistically significant in 9 cases and statistically insignificant in 17 instances.

Fiber strength. As regards this fiber property, 17 of the beta coefficients were identified by a positive sign and 9 by a negative one. Only 4 of the cases, however, were statistically significant--3 being positive and 1 negative. Therefore, on the basis of the majority of the statistically significant beta coefficients obtained with these groupings of cotton, the higher the tensile strength of the fibers the larger was the number of neps per 100 square inches of card web. In the case of one of the statistically significant beta coefficients, however, the reverse was true.

The finding of a positive relationship between fiber strength and nep count in card web for three out of the four statistically significant cases may come as a surprise to many readers of this report, as in the past a negative relationship between those two variables generally has been thought to be the case. Within the range of strength for these cottons, it may be that the relatively weak fibers break instead of nepping, whereas the stronger fibers withstand the pull into knots and remain as neps. There may be, of course, an incidental association between fiber strength and nep count in card web, although with little or no cause-and-effect relationship. Or, there may be an appreciable correlation between fiber strength and some other fiber property or condition not included in these analyses but which is a factor of importance to the number of neps per 100 square inches of card web.

The remaining 22 beta coefficients evaluating the effect of fiber strength on nep count in card web are statistically insignificant. Of these, 14 carry a positive sign and 8 a negative one. Fluctuations in signs for these statistically insignificant beta coefficients, as previously explained, are considered to be without meaning and their occurrence is not surprising.

Fiber fineness (weight per inch). Of the 26 cases, fiber fineness caused a statistically significant effect on nep count in card web 8 times and 7 of these cases carried a negative sign. The latter fact indicates that, in all cases except one, the coarser the fiber the smaller was the number of neps per 100 square inches of card web and, conversely, the finer the fiber the larger was the nep count in card web.

In one group, the Coker 100 cottons (all strains), it was found that fiber fineness exerted a positive effect on nep count in card web; that is, the coarser the fiber was the larger was the number of neps. What the explanation is for this apparent reversal or inconsistency is not readily evident. Variations of fiber weight per inch, when the samples are analyzed by varietal groupings, generally are induced by growth or environmental conditions. But, inasmuch as in this group of samples several strains of the Coker 100 variety were represented, some of the variations of fiber weight per inch may be of a varietal or genetic nature.

The remaining 18 beta coefficients for fiber fineness in relation to nep count in card web were found to be statistically insignificant and 16 of these indicated a negative relationship for the two variables concerned.

Percentage of mature fibers. In 6 cases out of the total 26, percentage of mature fibers produced a statistically significant effect on neps per 100 square inches of card web and the relationship was negative in all of these. That is, the larger the percentage of mature fibers in cotton the smaller was the nep count in card web, and vice versa. The other 20 beta coefficients were statistically insignificant and 14 of these indicated a negative relationship.

Fiber length uniformity ratio. Of the 26 beta coefficients evaluating the net effect of length uniformity ratio on nep count in card web, 5 of these were statistically significant and all carried a negative sign. Thus, in all of the statistically significant cases, the more uniform the fiber lengths in a cotton the smaller was the number of neps per 100 square inches of card web, and vice versa. The remaining 21 beta coefficients were statistically insignificant, 13 of them being negative and 8 positive.

EQUATION FOR ESTIMATING THE NUMBER OF NEPS IN CARD WEB

The multiple regression equation representing the entire series of 828 cottons and showing the relationship between number of neps per 100 square inches of card web and the 6 collective fiber properties, and the pertinent statistical values obtained, are as follows:

	\bar{R}	\bar{R}^2	\bar{S}
$X'_{70} = +76.41 - .431X_{88} + 31.401X_{17} - .472X_{19} - 2.690X_4 - .276X_{35} + .260X_{33}$	0.541	0.293	+ 9.5

Where:

- X'_{70} = number of neps per 100 square inches of card web
- X_{88} = grade index of cotton
- X_{17} = upper half mean length, in inches
- X_{19} = uniformity ratio, expressed as an index
- X_4 = fiber weight per inch, in micrograms
- X_{35} = percentage of mature fibers
- X_{33} = fiber strength (Pressley), in 1,000 pounds per square inch

ILLUSTRATION OF CALCULATIONS NECESSARY FOR ESTIMATING NUMBER OF NEPS IN CARD WEB

The method used for estimating the number of neps per 100 square inches of card web by the over-all general equation developed for the entire series of cottons is here illustrated by using the fiber data for the same cotton that served as the basis of the example for yarn appearance in publication (41) and for count-strength product in publication (40).

Substitutions are made in the equation given previously, as follows:

X₈₈ = 100 grade index corresponding to Middling (see table 3)
X₁₇ = 1.05, upper half mean length by fibrograph, in inches
X₁₉ = 77, uniformity ratio expressed as an index
X₄ = 4.3, fineness of fiber in micrograms per inch
X₃₅ = 81, percentage of mature fibers
X₃₃ = 69, tensile strength of the fiber in terms of 1,000 pounds per square inch

Constant term	+ 76.41
- .431 x 100 =	- 43.10
+31.401 x 1.05 =	+ 32.97
- .472 x 77 =	- 36.34
-2.690 x 4.3 =	- 11.57
- .276 x 81 =	- 22.36
+ .260 x 69 =	+ 17.94
Total =	+ 13.95

Estimated number of neps per 100 square inches of card web.... 14
Actual number of neps per 100 square inches of card web..... 11
Difference between estimated and actual number of neps..... 3

Thus, with this particular cotton, the estimated nep count in card web is only 3 neps per 100 square inches greater than the actual number which did occur.

SOME CONSIDERATIONS FOR POSSIBLE IMPROVEMENT IN EVALUATIONS OF RELATION- SHIPS PERTAINING TO NEPS

Although the statistical values and discussions presented in this paper have been reported as referring to the relationships between nep count per unit of area in card web and the six elements of cotton quality included, they do not refer to such per se. Rather, the results refer more particularly to the relationships between the measures that have been used

for those variables. This qualification always must be borne in mind when considering the results of this study and others of this series, as well as those from all other investigations bearing on the relationships of cotton fiber properties to performance in manufacturing and quality of manufactured product.

Curvilinear relationships. The comparatively low correlation values that have been reported to occur between the number of neps per 100 square inches in card web and the various elements of cotton quality used in this study suggest the possibility of the existence of curvilinear relations between the variables involved. Multiple curvilinear correlation analyses, however, have been applied to the data representing the entire series of 828 cottons. The findings have failed to show any higher degree of relationship between nep count in the card web and the 6 factors of cotton quality for this large number and wide range of cottons than did the multiple linear analyses.

Correlation results recently obtained by Gulati (8) generally support the findings of the study referred to above. By using a series of 30 current and standard Indian cottons, he made simple correlation analyses on data representing the number of neps per yard and per gram of yarn of 9 sizes, ranging from 6s to 40s, with fiber length and with a so-called fiber immature component. The latter is the product of the percentage of fibers in a sample longer than 1 inch multiplied by the percentage of immature or thin-walled fibers occurring within those length groups.

Gulati developed a linear regression equation for expressing the relationship between yarn-nep number and his fiber immaturity component. On comparing the estimates of yarn neps obtained by use of that equation with the values actually observed, he found a mean deviation of 41 percent. As this deviation was too much and as plots of the data indicated that their distribution was not entirely linear, Gulati sought a better average line fit to the data by the development of the second degree parabolic equation. The calculated values yielded by this curvilinear equation, however, improved the yarn-nep estimates only slightly -- to the extent that the mean deviation was still 36 percent.

Pearson (17) made extensive studies on neps in 672 duplicate lots of 22s yarn, representing 16 varieties of upland cotton grown at 8 locations across the rainfall part of the American Cotton Belt during the three crop years of 1935, 1936, and 1937. Through covariance analysis, simple correlation coefficients were calculated for each source of variance to show the relations of the number of neps in 22s yarn to fiber upper quartile length (sorter), fiber weight per inch, and the percentage of thin-walled fibers. Beta regression and multiple-correlation coefficients also were calculated for variety, stations, and years taken as a whole. No reference was made by Pearson in her report (17) to any possible curvilinear relations between the variables involved, so it may be assumed

that she observed no tendencies or indications of such in her data. Considering the large number and wide scope of cottons used in this study, as well as the wide range of varietal, locational, and seasonal effects which her data represented, it is felt that if any appreciable curvilinear relationships or tendencies were going to occur, they would have done so in this instance.

Nep count in card web. With respect to the dependent variable used in this instance, namely, number of neps per 100 square inches of card web, it is recognized that the measure for this variable is not perfect. It is, however, one of the best and most easily obtained measures available for this factor. Obviously, when different card webs represent a given textile processing organization, settings, and speeds, and when the card webs are identified with card slivers of the same weight specification - as in this study and report - the per-unit area measure used for the frequency of neps serves well for comparative purposes. It should be pointed out, however, that this nep-count measure considers a nep a nep, whether it is large or small, whether grossly macroscopic or almost microscopic in size, and irrespective of its shape, density, or origin. Therefore, if an improved and more adequate measure for nep count per unit of area or per unit of weight in card web could be developed and used in such statistical analyses, it is probable that better correlation results would be obtained than here reported.

In this connection, it may be pointed out that nep counts expressed on the basis of 100 square inches of card web or any unit per area of such material are not comparable between mills or for a given mill unless the weight of the card web or card sliver is the same. For purposes of comparison under such conditions, therefore, it is necessary to convert values from number of neps per unit of area in card web to number of neps per unit of weight. Some mills and other laboratories weigh the selected sample of card web, after counting, and express their results as the number of neps per grain or per gram. Such a method, however, involves the extra and tedious operation of carefully weighing the test specimen on a sensitive analytical balance. The weighing of such small quantities of material, however, is subject to some error, which may affect the resulting nep count per grain or per gram appreciably, unless all handling and weighing of samples are done with the greatest possible care.

As recently shown by Bogden (4), when the weight of card sliver is known, it is possible and simpler to convert mathematically nep-count readings per unit of area of card web to values per unit of weight. In his paper, Bogdan gave equations showing the relationship between the various standard methods of expressing degrees of neppiness, as generally used today, and included a nomograph which greatly expedites the conversion operations. His nomograph also provided conversion of nep-count values for card web into number of neps per 100 yards of 22s yarn. The

latter conversion assumes no further change in the number of neps between the carding and spinning processes. Drafting of the fibers in various textile processes, however, is known both to make and to remove neps from running stocks. Therefore, with various cottons and diverse processing conditions, the final net number of neps per 100 yards of a given size of yarn may be increased or decreased somewhat, or remain approximately the same. The influence of carding, combing, and drafting on the number of neps per unit of area or weight in various products and wastes from different textile machines is considered further in the Discussion chapter.

Although the number of neps per 100 square inches of card web was used as the dependent variable in the correlation analyses covered in this report, better statistical values than here reported would not be expected from using nep count of card web expressed either as per grain or per gram. This is true because all 828 cottons of this series were processed by the same textile machine organization, settings, and speeds and by the fact that all resulting card webs and card slivers represented practically the same respective weights.

Fiber length uniformity ratio. If the coefficient of fiber length variability (sorter) had been used in these statistical analyses in place of the uniformity ratio (fibrograph), the correlation values for the relation of nep count in card web to the six elements of cotton quality, probably would have been larger than those reported here, and the importance of the fiber length-uniformity factor to nep count probably would have been found to be greater. Such alternative data, however, were not available, as no sorter length tests were made on these samples of cotton. Limitations in the measure of uniformity-length ratio for such correlation purposes and the need for a more accurate and representative measure of the fiber length distribution actually occurring in a sample of cotton has been pointed out in previous reports from this series (34), (35), (41).

Fiber maturity or immaturity. The measure used for evaluating and expressing different degrees of cotton fiber maturity in the analyses covered by this report and previous ones in this series was the one used in these laboratories for over 20 years and described in Cotton Testing Service (30) and in ASTM Standards on Textile Materials (2). This method, in some particulars, is a modification of the so-called Clegg method which was developed in England about 30 years ago. Both the original method and the present one, which is modified, require swelling of the fibers in an 18 percent sodium hydroxide solution (NaOH) merely for the purpose of enabling the operator to be able to classify the fibers more easily, quickly, and positively, according to various degrees of fiber-wall thickness, maturity, or immaturity, than otherwise would be possible in the absence of such chemical treatment. A more or less arbitrary criterion, however, has been used in all applications of this method for differentiating between the various categories of fiber types and for determining the percentages of the various fiber-wall types. The

criterion used for fiber maturity and immaturity ratings in the tests and analyses covered in this report, was as follows: Fibers having a thickness of wall equal to or less than one-half the diameter of the lumen were classified as thin-walled or immature fibers, and all fibers having a thickness of wall greater than one-half the diameter of the lumen were classified as thick-walled or mature fibers.

Thus, on the basis of this criterion, no consideration was given to variations in the proportion of the fiber maturity ratings throughout the various length groups of the samples or to variations in the proportion of intermediate fiber-wall types that occur within each of the two broad categories defined. Both kinds of variation in fiber-wall types, however, occur and are ever present when any large number and wide range of cottons are involved, as in this study. Moreover, the criterion used in this instance does not permit a classification and counting of the fibers of the more extremely thin-walled types, irrespective of length, such as generally are found in greatest abundance of the fiber types occurring in neps and commonly thought to be the principal fiber type causing neps. Nor does this criterion permit a classification and counting of the more extremely thin-walled types occurring only within the longer fiber groups of a sample, such as frequently are found in substantial proportions in neps and considered by many to be the more particular fiber component giving rise to neps.

In the light of the foregoing, therefore, it is possible for samples having the same over-all percentage of thick-walled fibers to have appreciable variations in the proportion of their extremely thin-walled fibers as a whole and among their longer fibers in particular. Likewise, it is possible for samples possessing very different total percentages of thick-walled fibers to have the same percentage of extremely thin-walled fibers as a whole or among the longest fibers. Such variations in the percentage of very thin-walled fibers, while not expressible by the measure used in this study, probably influence the formation of neps and the resulting nep count. Therefore, if a more comprehensive measure for the factor of fiber maturity than the over-all percentage of mature fibers had been used in these analyses, better correlation results probably would have been obtained, and the importance of the contribution of fiber maturity or immaturity to nep count likely would have been found greater than here reported.

The point of view expressed above is supported by some correlation results along this line which Gulati (8) recently reported from his study of 30 current and standard Indian cottons. He found that, after elimination of 3 of the cottons, the number of neps per gram or per yard of yarn was highly correlated with the immature component of fibers longer than 1 inch (product obtained by multiplying the percentage of fibers longer than 1 inch in a sample by its percentage of thin-walled fibers among such fibers).

More particularly, for those Indian cottons, Gulati found the coefficient of simple correlation (\bar{r}) to be + 0.786 for the relationship between the immature component of long fibers and number of neps per yard of yarn. With elimination of one of the samples from the series (Cambodia), however, the simple coefficient of correlation for the two variables mentioned was raised to + 0.893 for the 29 remaining cottons. The values reported by Gulati are larger than the value of 0.541 reported in this paper for the coefficient of multiple correlation (\bar{R}) representing the entire series of 828 cottons, when the number of neps per 100 square inches of card web was correlated with 6 elements of raw cotton quality. The highest \bar{R} value obtained in the present study was 0.739 for the 117 samples representing the 1947 Experiment Station Annual Variety Series and the next highest \bar{R} value was 0.714 for the 78 samples representing the first picking from the 1946 selected cotton improvement groups. For the 25 subgroupings of samples by crop year, variety, staple length, and pairs of adjacent staple lengths, however, the \bar{R} values ranged from the maximum cited to a minimum of 0.398 for the 160 samples representing only 1-1/16 inches in staple length.

Recently, Calkins (6) described a method which classifies as thin-walled only 10 to 15 percent of the fibers in normal American upland cotton instead of the 30 percent usually found by the ASTM caustic-soda method (2), (30). Calkins concluded, on the basis of his studies of neps and experience, that this is a more reasonable and accurate standard for cotton fiber maturity than the two-to-one lumen to wall ratio called for by the ASTM method. There is considerable merit in the proposal by Calkins but, not unlike many suggestions with respect to the measurement, evaluation, and standardization of cotton fiber properties and other elements of raw cotton quality, it may be that his method of approach somewhat oversimplifies the problem. That is, it probably will be very difficult, if not impossible, to find any one method or single criterion for fiber maturity that will serve best all specialized and practical purposes. For example, the best criterion for classifying the various types in cotton samples with respect to fiber cell-wall development, may prove to be one thing for neps proper; another thing for rough and neppy yarns, or yarn appearance in the gray state; something else for appearance of yarns and fabrics in the dyed or finished state; something else for yarn strength, yarn elongation, or yarn elasticity; and still something else for comparing and evaluating raw cotton samples for purposes of cotton breeding and improvement, commercial marketing, and general utilization. Some compromises, therefore, will have to be made when adopting any single measure for rating fiber maturity in cotton samples.

Moreover, the criterion for cotton fiber maturity that gives the best correlation values with the counted number of neps per unit of length or weight of yarns may not necessarily give the best correlation values with the appearance of yarns and fabrics in either the gray or dyed states, as viewed visually. That is, when observations and evaluations

of yarn and fabric appearance are made by the human eye, psychological factors also exert their influence. More particularly, opportunities and possibilities for fluctuations and differences in such results may occur when the preponderance of neps present in yarns and fabrics are exceedingly small or rather large (generally, the smaller the neps the more they escape casual observation by the eye, although often the larger is the nep count, and vice versa); when the neps in yarn and fabrics are caused primarily by the more-or-less normal thin-walled fibers from the seed proper; when there are more typically matted thin-walled fibers from large motes (aborted or immature seeds) or from bolls damaged by insect, bacterial, or fungous attack; when so-called fuzz fibers are put into the ginned lint by ginning the seed too close; when different colors of dye are used (the presence of neps being more conspicuous in yarns and fabrics with some colors than others); or when certain dyes are used (some have a tendency to cover up neps and the matted clumps of thin-walled fibers, while others penetrate them only moderately or penetrate them deeply). These examples illustrate how very complex the nep problem really is; how difficult it is to make proper evaluations of the factors causing neps; how easy it is to oversimplify the method of approach adopted for experimentation and analysis; and how difficult or impossible it is to make sound generalizations and broad recommendations on the basis of limited data.

In 1934, Peirce and Lord (18) reported a new method that they had developed for expressing the percentages of normal fibers and so-called dead or extremely thin-walled fibers, occurring throughout a sample of cotton, as a single measure. These investigators called their measure the "maturity ratio" because of the manner in which it was calculated and in order to distinguish it from values more commonly used for expressing the percentage of mature or immature fibers in a sample. Several different modifications and refinements of this measure were made during the course of its development. In Lord's latest paper (11) (see footnote at bottom of page 186 of his paper) he stated: "The maturity ratio combines the percentage of normal (N) and dead (D) fibers into a single measure and is equal to $(N - D)/200 + 0.70$." This maturity-ratio measure would seem to possess considerable merit and be worthy of careful attention.

It is possible, if not probable, that the correlation findings presented in this report on the relations of nep count in card web to fiber properties of the raw cotton would have been improved if the measure for cotton fiber maturity suggested by Calkins (6), or the one used in India by Gulati (8), or the one developed in England by Peirce and Lord (18) had been applied. But, in the absence of such comparable data, it is impossible to say how much. What is needed to clarify such considerations, therefore, is the development of a proper foundation of comparative data adequate for correlation purposes; that is, the conduct of some specially designed tests and analyses on a limited series of selected cottons, yarns, and fabrics, using the principal measures available for fiber maturity. It also would seem important to determine

the variability in the proportion of mature and immature fibers throughout each sample in connection with any over-all percentage of mature or immature fibers for a sample, and to make multiple statistical analyses both with and without the measure representing the variability in frequency of the different fiber-walled types throughout the various length groups.

Exceptional and inconsistent results. With any given method or criterion for making cotton fiber maturity evaluations, sporadic and erratic results may be expected from time to time. These occur because all the relationships and interactions involved, representing many biological and mechanical factors, as well as the operation of some limiting factor within or beyond the experimental system, either have not been taken into account or else they were not thoroughly understood. If an investigator has not found erratic and sporadic results with cotton fiber maturity in relation to neps, from time to time, it is a strong indication that he has not studied a sufficiently large number and wide range of raw cottons and their textile products.

Gulati (8), by reporting his findings according to subseries of samples and some individual cottons, has shown what can happen when one, two, or three so-called erratic cottons are included in or excluded from correlation analyses representing a limited number of cottons. His results were obtained from simple correlation analyses on the relations of either the number of neps per yard or per gram of yarns to the proportion of 1/4-inch fibers and fibers longer than 1 inch collectively, or to the proportion of fibers longer than 1 inch alone, or to the immature component of either in the raw cotton. For the current Indian cottons which he studied, the coefficients of such simple correlations with number of neps per yard of yarn for 11 samples were just on the border line of significance at the 5-percent level, the values ranging from + 0.594 to + 0.622. But, the values for 10 selected cottons out of the series, were almost perfect, ranging from + 0.975 to + 0.985. Thus, one of the 11 cottons (variety Jarila Akulkheda) did not follow the pattern of the other 10 cottons, and its presence in or absence from the series greatly influenced the correlation values reported.

For the standard Indian cottons which he studied, Gulati found from similar correlation analyses that the immature components in all the 20 standard cottons did not maintain the high degree of correlation obtained with the current samples. The standard cottons, however, did show an improved relationship by elimination of two of the cottons from the series (Cambodia Co. 2 and Sind Sudhar).

What was the cause or causes for the apparent erratic behavior in the correlations for the three cottons cited above? The Sind Sudhar cotton had more neps in it than could be accounted for on the basis of its long and immature fibers. A comparison of the fiber data for the

saw-ginned sample with those data for the roller-ginned sample indicated that the increased neppiness of the saw-ginned sample was associated with a decrease in the proportion of its long fibers. Evidently, the saw gin had broken the long immature fibers and provided extra material for an additional number of neps.

As to the Jarila (Akulkheda) cotton, its erratic behavior in the correlation was due to a relatively high nep content and a comparatively small long fiber content. However, this cotton had the largest number of matted fiber neps of the cottons in the series studied and also a very large proportion of neps with more than 70 percent immature fibers in their composition. It was probable, Gulati says, that the immature fibers which went into the composition of the neps were derived in considerable part from the matted fibers as well as from the small percentage of long immature fibers.

In the case of Cambodia Co. 2 cotton, despite the high proportion of long immature fibers, the number of neps per yard of yarn was rather low. No explanation for the erratic finding with this cotton had been found by Gulati at the time of reporting.

Clegg (7), on the basis of seven sets of data out of eight, representing British Empire cottons of Uganda, Sudan American, Tanganyika and Nigerian growths from Africa, reported that she found a very definite relationship between Peirce and Lord's so-called maturity ratio measure of the raw cottons and the neppiness of 50s or 60s yarn. That is, as the maturity ratio of the cottons decreased, the degree of their neppiness increased. She also found this to be true when comparing samples within the same type of cotton. In the Sudan American group of samples, however, two of the most mature cottons produced the neppiest yarns. In these cases, the neps were found to be primarily of seed-coat origin and, when they were discounted and only the number of so-called dead and immature neps were counted, the tendency of neppiness to increase with fiber immaturity was again evident.

From another experiment on the relation of immaturity of the cotton to the appearance of the dyed and finished fabric, Clegg reported that the two cottons with the highest fiber maturity ratios produced both the neppiest gray yarns and the neppiest dyed yarns. This result, said Clegg, was wholly contrary to her experience with the other sets of gray yarn and raised an important finding with regard to the incidence of neps in raw cotton.

Clegg asked: "What then is the significance of the immaturity count in relation to neppiness? The immaturity count gives a figure for the general degree of thickening of the cotton. It is conceivable however that a cotton may have the majority of its hairs normally thickened, giving a high maturity ratio, but its 10-20 percent of dead hairs (extremely thin-walled ones) may be distributed in small patches through the

cotton in such a manner that they nep up and are not removed in processing and thus survive through to the finished cloth. Another cotton which is generally immature may have the same percentage of dead hairs disseminated through the sample with the result that they get through the processing without nepping up."

In conclusion, wrote Clegg: "It would appear therefore that there are conditions of neppiness unaccounted for by the immaturity figure, and since in the cases mentioned, and in many of the cloths submitted to us (the Shirley Institute) the majority of the neps are homogeneous dead cotton neps, it would appear in many cases to be the sporadic presence of these small patches of dead hairs, scattered throughout the sample, which is the real cause of the trouble to the dyer and finisher."

Lord (11), in his comprehensive discussion of neps in cotton and their causes, also has called attention to some inconsistencies in apparent relationships between neppiness of cottons and fiber properties, along the lines of the foregoing findings.

Other fiber and ginned-lint properties. The coefficients of multiple correlation reported in this paper for the relations of 6 elements of raw cotton quality to number of neps per 100 square inches of card web might have been improved, if some additional fiber properties and factors of ginned-lint quality had been included in the analyses. This possibility is strengthened by the findings which Pearson (17) reported from her extensive statistical analyses of the association of number of neps in 672 duplicate 50-yard samples of 22s yarn with upper quartile length (sorter), fiber weight per inch, and percentage of thin-walled fibers, representing 16 varieties of upland cotton grown at 8 locations across the rainfall part of the American Cotton Belt during the three crop years of 1935-37. Pearson has summed up the situation on this subject very effectively, as follows:

"A fairly large part of the varietal variance in neppiness and much larger parts of the station and yearly variance remained unexplained. It is possible that the solution of the problem may be found in some other fiber or lint properties that vary with variety and respond in a very marked degree to factors that vary with location and season."

Harrison and Craig (10) recently have made a special study of the common imperfections occurring in cotton fibers for the purpose of determining (1) the growth factors contributing to the formation of such imperfections and (2) the importance of imperfections as factors which contribute to neppiness in spun cotton. Those investigators made an analysis of several hundred neps occurring in both carded and combed yarns which showed that neps were composed of 10 different elements. Although they obtained no conclusive proof that fiber imperfections were the cause

of such neps, they showed that more neps contained immature fibers than any other element. They also showed that fibers of large diameter and deformities were factors which contributed to neppiness, and thus to spinning difficulties, in greater proportion than their prevalence in cotton would indicate.

DISCUSSION

It is seldom, if ever, that a sample of either saw-ginned or roller-ginned cotton lint can be found which is absolutely free of neps. All commercial world cottons, whether they be of American, Egyptian, other African, Indian, Chinese, Russian, Peruvian, Brazilian, and West Indian origin, contain neps in more or less degree as a result of various causes of a biological, mechanical, and miscellaneous nature. So-called hand-ginned samples of any growth or type of cotton, however - if the fibers are first carefully "butterflied" on the seed, combed, paralleled, and gently pulled from the seed with a minimum of handling - should be free of neps.

No neps in unopened boll or seed cotton. Balls (3) reported on the basis of his pioneer studies 30 or more years ago, that neps do not exist in the living or unopened cotton boll, but are made by handling, by ginning, and especially by the carding machine in textile processing, from fibers with unduly thin walls. No true nep, in the generally accepted sense, has ever been found in the living or unopened boll by any investigator, before or after Balls, insofar as the authors of this report know.

Pearson (14) made extensive studies on the question "Do neps occur in seed cotton?" In a very careful and thorough manner, she has examined countless numbers of locks and seeds of various varieties and strains of upland cotton for the presence of neps, representing both rain-grown and irrigated cottons, as well as a considerable quantity of Sea Island cotton. Some of the cottons which she studied were especially selected for this purpose because they had a reputation for being exceedingly neppy. No true neps, however, as defined in publications (13), (14), (15), (17), were ever found by Pearson in any dry locks of seed cotton examined directly after removal from the boll. A few tangles of fibers were found in samples of hand-picked cotton but, in all cases, they appeared only in lots that had received considerable handling. The presence of tangles in those special instances, therefore, can be logically explained by the handling which the cotton received before examination.

Different viewpoints concerning nep formation. Two primary schools of thought have been long established in conversation and writing with respect to cotton neps and their causes. In cotton agriculture, often there is a tendency for its representatives to feel that the principal causes for neps in the cotton world are identified more particularly with faulty ginning or improper textile processing of its samples, or both.

Representatives of the textile industry, on the other hand, commonly think that the major causes for neps in the products which they manufacture lie more especially with the inherent fiber properties of their raw-cotton stocks and the mechanical handling which they received at the gin prior to arrival at the mill. Both points of view are correct, insofar as they go, but neither goes far enough to be comprehensive. More particularly and completely, the formation of neps reflects and represents the net sum of all interactions that occur between the physical and chemical properties and other conditions of the fibers, on the one hand, and their handling and mechanical processing, on the other hand, whether the latter takes place at the gin, mill, or elsewhere.

Generally speaking, it has been recognized for many years by workers in cotton agriculture, the cotton trade, and the textile industry that long, fine-fibered cottons with a relatively large percentage of thin-walled and extremely thin-walled fibers contain more neps after ginning and are more susceptible to nep formation during textile processing than short, coarse-fibered cottons having a comparatively small percentage of thin-walled fibers. Gradations of many degrees in nep count and potentialities for nep formation exist between those extreme categories.

All of the experimental evidence available indicates that thin-walled fibers of any degree, particularly those with only primary walls and characteristic cellulose or with extremely small amounts of secondary walls and accompanying cellulose, are the principal fiber types contributing to nep formation in cotton. Such types of fibers are more susceptible to bending, rolling, twisting, tangling, kinking, and knotting than the other more normal types of fibers generally occurring in cotton samples. Thus, the larger the proportion of thin-walled fibers in a sample and the greater their lengths, generally the more neppy is the resulting ginned lint and the greater are the difficulties in textile processing for making desirable or acceptable yarns and fabrics.

Moreover, the highly thin-walled fiber types possess little or no measurable strength per single fiber and, as such, they break more easily and to a greater extent during the processes of ginning and manufacture than do other types of fibers. And, when a thin-walled fiber breaks, two or more thin-walled fibers of shorter length result. As a result of ginning and textile processing, therefore, the absolute and relative numbers of thin-walled fibers in a sample of known weight may increase over the original numbers in the seed cotton stage, and the cotton actually may become worse with respect to neppiness than it was in the beginning.

Breakage of the apical ends of fibers occurs during ginning and textile processing to a greater extent with some varieties and types of cotton than others. These apical ends of fibers have been found particularly in neppy cottons by various investigators, and are thought to be a contributory cause to the formation of neps in such cottons.

Moisture content of the seed cotton at the time of ginning, as well as machine settings, speeds, and rate of feed during ginning, are factors known to influence the relative number of neps that appear in the ginned lint from a given lot of seed cotton. Certain textile processing organizations, settings, speeds, and humidities, moreover, are known to influence the formation and removal of neps to a greater extent than others.

An inherently neppy cotton, of course, may be handled with such individual care during laboratory ginning and experimental textile processing that its nep count will be relatively low. Procedures of this kind, however, are generally impracticable for adoption in commercial ginning and manufacturing. Conversely, a comparatively nep-free cotton can be so mechanically abused during the ginning and preliminary textile processes as to cause the formation of a relatively large number of neps and the cotton to be classified as neppy.

Change in number of neps during textile processing. Balls (3), during the early 1920's, made extensive studies and calculations on this subject. The neps present in the products and fibrous wastes from various textile machines was determined by counting the number present in samples weighing 0.1 gram. A typical set of data for such samples, including the raw cotton or ginned lint, was as follows:

<u>Sample used</u>	<u>Neps per gram of --</u>	
	<u>Product</u>	<u>Waste</u>
	<u>Number</u>	<u>Number</u>
Original lint	515	---
Card sliver	755	---
Card strips	---	3,080
Comber lap	688	---
First comber waste	---	1,772
First comber sliver	109	---
Second comber waste	---	676
Second comber sliver	93	---
Finishing draw-frame	152	---

Computing these figures further with the data available for waste, Balls found that the card increased the nep content from 500 to 1,000 per gram, but put away a quarter of this thousand in the waste. On the other hand, the combers did not alter the total nep content; the first comber put 80 percent of the number of neps into its waste, while the second comber only disposed of 30 percent of the remainder. The last figure in the tabulation shown above indicates that ordinary drafting can and does increase the number of neps in processed stock.

Balls' figures show well how the number of neps in processed stock is influenced by the action of different machines in the mill during the preliminary stages to spinning. The nep-making powers of the card are well known, though its low efficiency as a nep remover is not always fully realized. Any similar rubbing action, of course, will make neps. Balls reported that, in one arrangement accidentally produced during work on the Sorter (Balls' sledge sorter for distributing cotton fibers according to length), almost the whole of the cotton which passed through it was converted into neps.

Loveless (12) recently has studied an interesting question in this connection, namely, "What happens to cotton sliver, if it is passed through a conventional drawing frame over and over again"? Such an exploratory investigation was timely inasmuch as some research had shown that neps were formed during drafting. Tests were made by Loveless on a neppy cotton, Acala P-18C, 1-1/16 inches in staple length, and Middling in grade. In his studies, he increased the number of drawings to as high a number as could be run with the sliver holding together. Sliver weighing 55 grains per yard from a card with the generally accepted settings served as the stock material. Samples were taken for nep count and for spinning into yarns, after every five drawings. A 50s yarn was spun by long-draft processing, with a 5.0 twist multiplier. Various physical tests were made on the samples of yarn as well as on the raw cotton.

The results obtained by Loveless from this study are highly interesting. More particularly, the number of neps per gram of drawing sliver increased at a fairly uniform rate from 160 after 3 drawings to 340 after 33 drawings. Yarn appearance became progressively worse as the sliver was drawn up to 33 times primarily because of the increase in number of neps. With multiple drawing, yarn evenness showed a constant rate of decrease in the percentage of variation. Yarn elongation or stretch also decreased with the increase in number of drawings because of increased parallelization of the fibers and what was referred to as removal of "crimp" after several drawings. Yarn strength, on the other hand, improved with multiple drawing, the count-strength product increasing significantly and the results indicating a more uniform cross section as well as a better use of fiber strength.

While Loveless published in his report (12) only findings from the neppy P-18C cotton, he has informed the authors of this paper that he also conducted a similar multiple-drawing experiment on a Deltapine 14 cotton. The results obtained with the Deltapine cotton were similar to those with the P-18C cotton except that the number of neps for the Deltapine cotton was consistently smaller, as it was a less neppy cotton.

Development of cottons with low nep content and with reduced nep-forming potentialities. In considering this phase of the nep problem, it is only necessary to start with the established fact that neps are most frequent and pronounced in so-called immature cottons; that is, especially those containing a large proportion of extremely thin-walled fibers with little or no secondary thickening. General experience has

indicated that, if the proportion of such thin-walled fibers exceed about 20 to 25 percent of the total fibers, many cottons will show excessive neppiness. Complaints of neppiness, however, seldom arise when the proportion of such thin-walled fibers are less than approximately 10 percent. The degree of neppiness for intermediate cottons, say with 10 to 20 percent of such thin-walled fibers, generally is uncertain and, seemingly, to a considerable extent dependent on unknown factors.

For a number of years, in connection with their general hybridization and selection work, American commercial and experimental breeders gave attention to the problem of neppiness in cotton as best they could with the knowledge and techniques available to them at the time. Until recently, however, cotton breeders and improvement specialists were greatly handicapped in their work on the nep problem because of the fact that the relations of neps in ginned lint, processed card web, yarns and fabrics to individual and combined fiber properties had not been statistically evaluated nor precisely established. In spite of these limitations, nevertheless, there is considerable evidence to show that American cotton breeders have made definite progress in the development of better cotton varieties and strains with respect to neppiness.

During the last few years, George J. Harrison - as a cotton breeder for the U. S. Department of Agriculture and while serving more particularly the cotton-growing areas in the State of California - has studied the matter of fiber abnormalities, fiber imperfections, and fiber immaturity in their relation to growth factors and to nep formation. The resulting findings and conclusions are set forth by Harrison and Craig in publication (10). On the basis of such knowledge and this method of approach, Harrison has been able to make marked improvement in the neppiness of some of his more recent cottons especially adapted for and widely grown in California. This is an outstanding achievement and illustrates what can be done.

Further, after a critical review of extensive experimental evidence accumulated at the Shirley Institute in England up to the middle of 1948, Lord recently has summed up very effectively the situation and possibilities with respect to neps in cotton as related to the genetic factor. Lord's experimental data, statistical analyses, and findings are worthy of study. The last two paragraphs of Lord's publication (11) are quoted herewith, as follows:

We may therefore conclude that, after allowing for secondary effects of variations in fibre fineness and staple length, cottons of high fibre maturity are likely to give less neppy yarns than those of lower maturity. Further, the data are sufficient to establish that fibre maturity is partly determined by genetic factors which may produce markedly consistent differences in cottons grown under varying environmental conditions, even when those conditions are uniformly favourable to a high degree of development of secondary thickening.

As yet it is not possible to say anything definite regarding the nature of the genetic effects. No direct selection for fibre maturity has yet been carried out under critical and controlled experimental conditions, so that observed differences in maturity can only be regarded as fortuitous, having become established in the course of previous breeding for other plant and fibre characters. Until direct selection for fibre maturity is attempted it is neither possible to determine whether this character is highly polygenic or whether a limited number of major factors operate, nor to estimate the degree to which it is possible to build up potentiality for adequate secondary thickening. Nevertheless, the available evidence is sufficiently strong to assert that marked improvements in neppiness may be obtained by critical plant breeding methods designed to obtain improved fibre maturity, and that there is ample scope for this work in the field of the African-American cottons.

Thus, the challenge and opportunity to American cotton breeders and experimental biologists!

LITERATURE CITED

- (1) Abdelhafez, Osman Mohammed.
1950. Frequency of Neps in Yarns of Egyptian Cottons. Min. of Agr., Egypt. Tech. Bul. 253, 8 pp., illus.
- (2) ASTM Standards on Textile Materials.
1949. Methods of Testing Cotton Fibres; Tests and Tolerances for Cotton Yarns. 229-255, 256-261, illus. (Published annually by Amer. Soc. Test. Mat., 1916 Race St., Phila. 3, Pa.)
- (3) Balls, W. Lawrence.
1928. Studies of Quality in Cotton, pp. 114-115, illus. (Published by McMillan and Co., Ltd., London, England.)
- (4) Bogdan, J. F.
1949. Nomograph Gives Nep Count per Unit Weight. Textile World. 99, No. 10: 128-129. (October 1949.)
- (5)

1950. A Review of Literature on Neps. Textile Ind. 114, No. 1: 98-107, illus. (January 1950.)
- (6) Calkins, Edward W. S.
1946. Counting Thin-Walled Fibers in Cotton by Polarized Light. Text Res. Jour. 16: 171-173. (April 1946.)
- (7) Clegg, Gladys G.
1934. The Most Troublesome Impurities in Cotton - Bearded Motes and Neps. Empire Cotton Growing Corporation. Second Conference on Cotton Growing Problems. Report and Summary Proceedings. 252-266, illus. (Published in July 1934.)
- (8) Gulati, A. N.
1949. Causes of Neps in Indian Cotton Yarns. Ind. Central Cot. Com. Tech. Bul. Series B, 43: pp. 28, illus. (October 1949.)
- (9)

1950. Role of Some Structural Features of Cotton Fiber in Nep-Formation. (Paper discussed at the Fourth Conference on cotton growing problems in India, Bombay. February 1949.) Ind. Cot. Growing Rev. 4, No. 3, 133-142, illus. (July 1950.)
- (10) Harrison, George J., and Craig, Edna A.
1945. Cotton Fiber Imperfections and Their Probable Relation to Yarn Quality. Text. Res. Jour. 15: No. 7: 247-256, illus. (July 1945.)
- (11) Lord, E.
1948. Neppiness and Immaturity in Cotton. Emp. Cot. Grow. Rev. 25, No. 3, 180-190. (July 1948.)

- (12) Loveless, Howard.
1950. What Happens to Cotton in Multiple Drawing? Textile World.
100, No. 8: 110-111, illus. (August 1950.)
- (13) Pearson, Norma L.
1933. Neps and Similar Imperfections in Cotton. U. S. Dept. Agr.
Tech. Bul. 396, 18 pp. illus. (November 1933.)
- (14) ~~1936.~~ Do Neps Occur in Seed Cotton? Cot. Ginners' Jour. 7: No. 6:
5-6, 17. (March 1936.)
- (15) ~~1937.~~ Naps, Neps, Motes and Seed-Coat Fragments. U. S. Dept. Agr.,
Bur. Agr. Econ., 7 pp. illus. (Processed March 1937.)
- (16) ~~1939.~~ Relation of the Structure of the Chalazal Portion of the Cot-
ton Seed Coat to Rupture During Ginning. Jour. Agr. Res.
58: 865-873, illus. (June 1939.)
- (17) ~~1944.~~ Neps in Cotton Yarns as Related to Variety, Location and
Season of Growth. U. S. Dept. Agr. Tech. Bul. 878, 18 pp.,
illus. (December 1944.)
- (18) Peirce, F. T., and Lord, E.
1934. Studies in Variability of Cotton, with Special Reference to
Immaturity. Empire Cotton Growing Corporation. Second
Conference on Cotton Growing Problems. Report and Summary
Proceedings. 223-252, illus. (Published in July 1934.)
- (19) United States Department of Agriculture.
1938. The Classification of Cotton. U. S. Dept. Agr. Misc. Pub.
310. 54 pp. illus. (May 1938.)
- (20) ~~1946.~~ Results of Fiber and Spinning Tests for Some Varieties of
Cotton Grown in the United States, Crop of 1945. Prod. and
Markt. Admin. 33 pp. illus. (Processed, March 1946.)
- (21) ~~1946.~~ Fiber and Spinning Test Results for Some Upland Cottons Grown
in Selected Standardized-Variety Areas, Crop of 1946. Prod.
and Market. Admin. 13 pp. (Processed, December 1946.)
- (22) ~~1947.~~ Comparative Qualities, Yields, and Gross Returns for Lint and
Seed for Some Upland Cottons Grown at Florence, S. C.,
Crop of 1946. Prod. and Market. Admin. 9 pp. (Processed,
March 1947.)

- (23) United States Department of Agriculture.
1947. Comparative Qualities, Yields, and Gross Returns for Lint and Seed for Some Varieties of Cotton Grown at Texas Experiment Stations, Crop of 1946. Prod. and Market. Admin. 21 pp. (Processed, April 1947.)
- (24) ~~1947.~~ Fiber and Spinning Test Results for Some Pure Varieties Grown by Selected Cotton Improvement Groups, Crop of 1947. Prod. and Market. Admin. 15 pp. (Processed, November 1947.)
- (25) ~~1947.~~ Fiber and Spinning Test Results for Some Pure Varieties Grown by Selected Cotton Improvement Groups, Crop of 1947. (Supplement No. 1.) Prod. and Market. Admin. 5 pp. (Processed, December 1947.)
- (26) ~~1947.~~ Progress Report on the Annual Varietal and Environmental Study of Fiber and Spinning Properties of Cottons, 1946 Crop. Agr. Res. Admin., BPISAE. 45 pp. (Processed, April 1947.)
- (27) ~~1948.~~ Comparative Qualities, Yields, and Gross Returns for Lint and Seed for Some Cottons Grown at Florence, S. C., Crop of 1947. Prod. and Market. Admin. 13 pp. (Processed, March 1948.)
- (28) ~~1948.~~ Comparative Qualities of Some Varieties of Cotton Grown at Texas Experiment Stations, Crop of 1947. Prod. and Market. Admin. 17 pp. (Processed, June 1948.)
- (29) ~~1948.~~ Progress Report on the Annual Varietal and Environmental Study of Fiber and Spinning Properties of Cottons, 1947 Crop. Agr. Res. Admin., BPISAE. 49 pp. (Processed, June 1948.)
- (30) ~~1949.~~ Cotton Testing Service. Prod. and Market. Admin. 29 pp. illus. (Processed, October 1949.)
- (31) Webb, Robert W.
1947. Relation and Relative Importance of Some Cotton Fiber Properties to Certain Manufacturing Qualities. (Paper presented at a meeting of Fiber Society, New Orleans, La. It represents a summary and digest of the principal findings covered in the six reports under (32), (33), (34), (35), (36), (37), below. U. S. Dept. Agr., Prod. and Market. Admin. 22 pp. (Processed, February 1947.)
- (32) ~~1945.~~, and Richardson, Howard B.
Relationships Between Properties of Cotton Fibers and Strength of Carded Yarns. U. S. Dept. Agr., War Food Admin. 58 pp. illus. (Processed, March 1945.)

- (33) Webb, Robert W., and Richardson, Howard B.
1945. Relationships of Cotton Fibers to Strength and Elongation of Tire Cord. U. S. Dept. Agr., War Food Admin. 59 pp. illus. (Processed, June 1945.)
- (34) _____, and Richardson, Howard B.
1945. Comparative Significance of Alternative Cotton Fiber Length and Strength Measures in Relation to Yarn Strength. U. S. Dept. Agr., Prod. and Market. Admin. 62 pp. illus. (Processed, September 1945.)
- (35) _____, and Richardson, Howard B.
1946. Relationships Between Properties of Cotton Fibers and Appearance of Carded Yarns. U. S. Dept. Agr., Prod. and Market. Admin. 54 pp. illus. (Processed, March 1946.)
- (36) _____, and Richardson, Howard B.
1946. Relationships Between Properties of Cotton Fibers and Percentages of Wastes Associated With the Manufacture of Carded Yarns. U. S. Dept. Agr., Prod. and Market. Admin. 63 pp. (Processed, July 1946.)
- (37) _____, and Richardson, Howard B.
1947. Relation and Importance of Certain Fiber Properties of Long Staple Cottons to Strength and Appearance of Combed Yarns, and to Percentages of Manufacturing Waste. U. S. Dept. Agr., Prod. and Market. Admin. 84 pp. (Processed, July 1947.)
- (38) _____, Richardson, Howard B., and Popka, Doretta H.
1949. Relation of Six Elements of Cotton Quality to Strength of 22s Yarn (Regular Draft), by Crop Year, Variety, and Staple Length. U. S. Dept. Agr., Prod. and Market. Admin. 61 pp. (Processed, October 1949.)
- (39) _____, and Richardson, Howard B.
1950. Relation of Six Elements of Raw Cotton Quality to Strength of 22s and 50s Yarn (Long Draft). U. S. Dept. Agr., Prod. and Market. Admin. 63 pp. (Processed, April 1950.)
- (40) _____, and Richardson, Howard B.
1950. Relation of Count-Strength Product of Long-Draft Processed Yarn to Six Elements of Raw Cotton Quality and Yarn Size. U. S. Dept. Agr., Prod. and Market. Admin. 61 pp. illus. (Processed, August 1950.)
- (41) _____, and Richardson, Howard B.
1950. Relation of Appearance of Long-Draft Processed Carded Yarn to Six Elements of Raw Cotton Quality and Yarn Size. U.S. Dept. Agr., Prod. and Market. Admin. 53 pp. illus. (Processed, November 1950.)

APPENDIX

Table 1.— Manufacturing organization, settings, and speeds used at the spinning laboratories to process the small samples of cotton used in this study through the picker and card

Item	Specification
PICKER:	
Each test lot was processed twice through a finisher type picker to produce the specified	
weight of lap per yard	ounces 11
Width of picker lap	inches 40
Type of beater	Kirschner
Beater speed	r.p.m. 1,000
Settings:	
Feed roll to beater	inches 3/16
Grids to beater, top	do 5/16
Grids to beater, bottom	do 11/16
CARD:	
Feed, picker lap per yard	ounces 11
Width of card web	inches 40
Delivered one sliver per yard	grains 40
Production rate per hour	pounds 9½
Doffer speed	r.p.m. 10
Cylinder speed	do 165
Speed of flats per minute	inches 2-7/8
Licker-in speed	r.p.m. 435
Settings:	
Feed plate to licker-in	inches 0.010
Mote knife to licker-in, top	do .012
Mote knife to licker-in, bottom	do .010
Licker-in screen, front	do .029
Licker-in screen, back	do .017
Licker-in to cylinder	do .007
Flats to cylinder, back, center, and front.....	do .009
Back plate to cylinder, top	do .029
Back plate to cylinder, bottom	do .034
Front plate to cylinder, top	do .029
Front plate to cylinder, bottom	do .034
Doffer to cylinder	do .007
Cylinder screen, back	do .029
Cylinder screen, center	do .034
Cylinder screen, front	do 3/16
Doffer comb to doffer	do .022

Table 2.-- Laboratory classification of cottons on the basis of neppiness

Number of neps per 100 square inches of processed card web <u>1/</u>	Adjective rating
1 - 15	Low
16 - 25	Average
26 - 40	High
Above 40	Very high

1/ Based on a standard weight card sliver of 40 grains per yard from a 40-inch card.

Table 3.-- Code for obtaining the index value of raw cotton from its grade

Grade	: White : : and : : Extra : : White :	: Spotted :	: Tinged :	: Yellow : : stained :	: Gray :
SGM	: 106 :	:	:	:	:
GM	: 105 :	: 101 :	: 94 :	: 86 :	: 93 :
SM	: 104 :	: 99 :	: 91 :	: 81 :	: 91 :
M	: 100 :	: 93 :	: 82 :	: 73 :	: 84 :
SLM	: 94 :	: 83 :	: 75 :	:	: 75 :
LM	: 85 :	: 75 :	: 68 :	:	:
SGO	: 76 :	:	:	:	:
GO	: 70 :	:	:	:	:
Below Grade	: 60 :	:	:	:	:

Table 4.— Statistical values obtained from multiple correlation analyses for 6 cotton fiber properties with number of neps per 100 square inches of processed card web, by various groupings of samples, crop years 1945-47

Groups of cotton according to	Cottons:	Statistical values				Neps occurring per 100 square inches of card web				
		R	R ² x100	S		Mean	S. D.	Maximum	Minimum	Range
				Absolute	Relative					
Number	Percent	Number	Percent	Number	Number	Number	Number	Number		
Over-all, 1945-47	828	0.541 ± 0.025	29.3	+ 9.5	+ 57.6	16.5	+ 11.3	173	1	172
Selected cotton improvement groups:										
1946, 1st picking	78	.714 ± .056	51.0	+ 4.1	+ 21.8	19.0	+ 5.9	36	8	28
1947, 1st picking	86	.570 ± .073	32.5	+ 6.9	+ 40.3	17.0	+ 8.3	41	5	36
1947, 2d picking	80	.666 ± .063	44.3	+ 5.6	+ 31.3	17.8	+ 7.4	38	5	33
1947, 1st and 2d pickings	166	.601 ± .050	36.1	+ 6.3	+ 36.4	17.4	+ 7.9	41	5	36
Experiment Station Annual Variety Series:										
1945	210	.571 ± .047	32.6	+ 5.8	+ 35.6	16.4	+ 7.1	38	5	33
1946	257	.675 ± .034	45.5	+ 7.4	+ 51.8	14.4	+ 10.1	65	1	64
1947	117	.739 ± .042	54.6	+ 14.6	+ 78.4	18.6	+ 21.5	173	4	169
Variety:										
Coker 100 (all strains)	101	.539 ± .071	29.1	+ 6.3	+ 36.9	17.2	+ 7.5	33	4	29
Stoneville 2B	61	.519 ± .094	26.9	+ 7.5	+ 43.1	17.4	+ 8.7	53	4	49
Deltapine 14	124	.493 ± .068	24.3	+ 5.7	+ 33.5	17.1	+ 6.6	38	6	32
Rowden (all strains).....	46	.438 ± .121	19.1	+ 3.6	+ 37.8	9.5	+ 3.9	18	4	14
Acala 1517, 1517W, W-29, 2815 ..	50	.401 ± .120	16.1	+ 9.3	+ 37.4	24.8	+ 10.0	51	13	38
Staple length:										
7/8 inch	37	.597 ± .107	35.6	+ 3.4	+ 40.2	8.5	+ 4.2	25	3	22
29/32 inch	32	.561 ± .123	31.5	+ 5.3	+ 48.1	11.0	+ 6.3	33	4	29
15/16 inch	90	.675 ± .058	45.6	+ 7.0	+ 43.4	16.1	+ 9.4	47	4	43
31/32 inch	61	.652 ± .074	42.5	+ 4.3	+ 34.2	12.7	+ 5.7	28	4	24
1 inch	116	.569 ± .063	32.3	+ 6.8	+ 43.9	15.4	+ 8.2	53	5	48
1-1/32 inches	188	.459 ± .058	21.0	+ 8.6	+ 47.3	18.1	+ 9.6	65	4	61
1-1/16 inches	160	.398 ± .067	15.8	+ 6.0	+ 35.0	17.1	+ 6.5	46	4	42
1-3/32 inches	80	.489 ± .086	23.9	+ 6.4	+ 37.8	17.0	+ 7.3	41	7	34
Combination of staple lengths:										
7/8 inch and 29/32 inch	69	.582 ± .080	33.9	+ 4.4	+ 46.0	9.6	+ 5.4	33	3	30
15/16 inch and 31/32 inch	151	.674 ± .045	45.4	+ 6.1	+ 41.7	14.7	+ 8.3	47	4	43
1 inch and 1-1/32 inches	304	.461 ± .045	21.2	+ 8.2	+ 47.8	17.1	+ 9.2	65	4	61
1-1/16 inches and 1-3/32 inches	240	.400 ± .054	16.0	+ 6.2	+ 36.5	17.1	+ 6.8	46	4	42
31/32, 1, and 1-1/32 inches	365	.484 ± .040	23.4	+ 7.8	+ 47.4	16.3	+ 8.8	65	4	61

¹/ S. D. denotes standard deviation of nep count for the respective groups of samples.

²/ Based on mean number of neps per 100 square inches of card web for the respective groups of samples.

Table 5.— Relative net importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by series and year, crop years 1945-47

Groups of cotton according to —	: Cottons:	Fiber properties	: Rank :	Beta coefficient	1/
	: Number :				
Over-all, 1945-47	828	Upper half mean length	1	+0.239	+ 0.045
		Grade index	2	- .231	+ .031
		Fiber strength	3	+ .150	+ .031
		Fiber weight per inch	4	- .140*	+ .055
		Percentage of mature fibers	5	- .131	+ .038
		Uniformity ratio	6	- .129	+ .034
Selected cotton improvement groups, 1946, 1st picking	78	Fiber weight per inch	1	- .986	+ .166
		Upper half mean length	2	- .372*	+ .151
		Uniformity ratio	3	- .305	+ .086
		Percentage of mature fibers	4	+ .157*	+ .110
		Fiber strength	5	- .063*	+ .086
		Grade index	6	- .017*	+ .088
Selected cotton improvement groups, 1947, 1st picking	86	Fiber weight per inch	1	- .330*	+ .195
		Percentage of mature fibers	2	- .218*	+ .137
		Upper half mean length	3	+ .173*	+ .146
		Grade index	4	- .133*	+ .094
		Uniformity ratio	5	+ .109*	+ .104
		Fiber strength	6	- .007*	+ .100
Selected cotton improvement groups, 1947, 2d picking	80	Percentage of mature fibers	1	- .431	+ .115
		Fiber strength	2	- .263	+ .086
		Uniformity ratio	3	- .153*	+ .097
		Grade index	4	- .093*	+ .086
		Fiber weight per inch	5	- .077*	+ .166
		Upper half mean length	6	+ .059*	+ .132
Selected cotton improvement groups, 1947, 1st and 2d pickings	166	Percentage of mature fibers	1	- .339	+ .089
		Upper half mean length	2	+ .193*	+ .095
		Fiber weight per inch	3	- .150*	+ .127
		Fiber strength	4	- .138*	+ .066
		Grade index	5	- .070*	+ .066
		Uniformity ratio	6	+ .003*	+ .072

See footnotes at end of table.

Table 5.— Relative net importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by series and year, crop years 1945-47 — Continued

Groups of cotton according to --	: Cottons: :	Fiber properties	: Rank: :	: Beta coefficient ^{1/} :
	: Number: :		: : :	
Experiment Station :	210 :	Fiber weight per inch	: 1 :	-0.334 + 0.091
Annual Variety :	:	Grade index	: 2 :	- .329 + .069
Series, 1945 :	:	Fiber strength	: 3 :	+ .144* + .061
:	:	Uniformity ratio	: 4 :	- .132* + .065
:	:	Upper half mean length	: 5 :	- .078* + .089
:	:	Percentage of mature fibers	: 6 :	+ .020* + .069
	:		: : :	
Experiment Station :	257 :	Uniformity ratio	: 1 :	- .311 + .060
Annual Variety :	:	Fiber weight per inch	: 2 :	- .299* + .108
Series, 1946 :	:	Grade index	: 3 :	- .172 + .053
:	:	Fiber strength	: 4 :	+ .162 + .052
:	:	Upper half mean length	: 5 :	+ .071* + .081
:	:	Percentage of mature fibers	: 6 :	- .042* + .071
	:		: : :	
Experiment Station :	117 :	Grade index	: 1 :	- .541 + .074
Annual Variety :	:	Upper half mean length	: 2 :	+ .419 + .094
Series, 1947 :	:	Fiber strength	: 3 :	+ .333 + .074
:	:	Percentage of mature fibers	: 4 :	- .258 + .075
:	:	Uniformity ratio	: 5 :	+ .142* + .074
:	:	Fiber weight per inch	: 6 :	+ .109* + .111
	:		: : :	

^{1/} The sign indicates the direction of the contribution of the fiber property to nep count.

* Statistically insignificant, being less than 3 times its standard error.

Table 6.--Relative net importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by variety, crop years 1945-47

Variety	Cottons	Fiber properties	Rank	Beta coefficient ^{1/}
	Number			
Coker 100 (all strains)	101	Fiber weight per inch	1	+0.524 + 0.143
		Grade index	2	- .478 + .096
		Percentage of mature fibers	3	- .450 + .114
		Uniformity ratio	4	- .240* + .112
		Upper half mean length	5	+ .226* + .107
		Fiber strength	6	+ .211* + .096
Stoneville 2B	61	Percentage of mature fibers	1	- .433* + .160
		Grade index	2	- .341* + .124
		Fiber strength	3	+ .232* + .120
		Fiber weight per inch	4	+ .039* + .190
		Uniformity ratio	5	+ .015* + .160
		Upper half mean length	6	- .010* + .132
Deltapine 14	124	Grade index	1	- .384 + .085
		Percentage of mature fibers	2	- .206* + .107
		Fiber weight per inch	3	- .151* + .115
		Upper half mean length	4	- .139* + .095
		Uniformity ratio	5	+ .110* + .089
		Fiber strength	6	+ .054* + .082
Rowden (all strains)	46	Fiber weight per inch	1	- .393* + .285
		Upper half mean length	2	- .307* + .205
		Percentage of mature fibers	3	- .203* + .238
		Uniformity ratio	4	- .165* + .160
		Fiber strength	5	- .088* + .147
		Grade index	6	- .010* + .146
Acala 1517, 1517W, W-29, 2815	50	Fiber strength	1	- .450* + .195
		Upper half mean length	2	- .435* + .167
		Fiber weight per inch	3	- .424* + .165
		Percentage of mature fibers	4	+ .151* + .138
		Uniformity ratio	5	- .058* + .144
		Grade index	6	- .054* + .148

^{1/} The sign indicates the direction of the contribution of the fiber property to nep count.

* Statistically insignificant, being less than 3 times its standard error.

Table 7.-- Relative net importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by staple length, crop years 1945-47

Staple length	Cottons:	Fiber properties	Rank	Beta coefficient	1/
	Number				
7/8 inch	37	Uniformity ratio	1	-0.697	+ 0.177
		Upper half mean length	2	-.291*	+ .174
		Fiber weight per inch	3	-.203*	+ .186
		Percentage of mature fibers	4	+.101*	+ .186
		Fiber strength	5	+.072*	+ .170
		Grade index	6	-.067*	+ .158
29/32 inch	32	Uniformity ratio	1	-.354*	+ .195
		Grade index	2	-.273*	+ .169
		Percentage of mature fibers	3	-.210*	+ .238
		Fiber weight per inch	4	-.069*	+ .263
		Upper half mean length	5	-.012*	+ .168
		Fiber strength	6	-.005*	+ .168
15/16 inch	90	Percentage of mature fibers	1	-.338*	+ .122
		Uniformity ratio	2	-.286*	+ .098
		Grade index	3	-.250*	+ .085
		Fiber weight per inch	4	-.146*	+ .130
		Fiber strength	5	+.129*	+ .094
		Upper half mean length	6	-.070*	+ .098
31/32 inch	61	Fiber weight per inch	1	-.353*	+ .162
		Percentage of mature fibers	2	-.341*	+ .125
		Grade index	3	-.175*	+ .108
		Upper half mean length	4	-.168*	+ .116
		Fiber strength	5	+.117*	+ .113
		Uniformity ratio	6	-.078*	+ .153
1 inch	116	Uniformity ratio	1	-.265*	+ .089
		Grade index	2	-.257*	+ .086
		Fiber weight per inch	3	-.254*	+ .115
		Upper half mean length	4	-.168*	+ .095
		Fiber strength	5	+.036*	+ .091
		Percentage of mature fibers	6	-.022*	+ .099

See footnotes at end of table.

Table 7.— Relative net importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by staple length, crop years 1945-47 -- Continued

Staple length	Cottons:	Fiber properties	Rank	Beta coefficient ^{1/}
	Number			
1-1/32 inches	188	Fiber weight per inch	1	-0.452 + 0.100
		Fiber strength	2	+ .134* ± .068
		Grade index	3	- .122* ± .071
		Percentage of mature fibers	4	+ .095* ± .082
		Uniformity ratio	5	+ .050* ± .077
		Upper half mean length	6	+ .026* ± .076
1-1/16 inches	160	Fiber weight per inch	1	- .355 + .108
		Grade index	2	- .193* ± .079
		Fiber strength	3	- .101* ± .078
		Uniformity ratio	4	+ .062* ± .079
		Upper half mean length	5	- .048* ± .084
		Percentage of mature fibers	6	- .025* ± .092
1-3/32 inches	80	Fiber strength	1	+ .312* ± .114
		Percentage of mature fibers	2	- .222* ± .126
		Fiber weight per inch	3	- .197* ± .147
		Upper half mean length	4	+ .166* ± .116
		Uniformity ratio	5	- .077* ± .116
		Grade index	6	- .043* ± .105

^{1/} The sign indicates the direction of the contribution of the fiber property to nep count.

* Statistically insignificant, being less than 3 times its standard error.

Table 8.-- Relative net importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by combination of staple lengths, crop years 1945-47

Combination of staple lengths	: Cottons:	Fiber properties	: Rank	: Beta coefficient ^{1/}
	: Number :			
7/8 inch and 29/32 inch	: 69 :	: Uniformity ratio	: 1	: -0.409 + 0.120
		: Grade index	: 2	: - .207* + .104
		: Fiber weight per inch	: 3	: - .166* + .147
		: Percentage of mature fibers	: 4	: - .091* + .136
		: Upper half mean length	: 5	: + .039* + .112
		: Fiber strength	: 6	: - .010* + .106
15/16 inch and 31/32 inch	: 151 :	: Percentage of mature fibers	: 1	: - .338 + .084
		: Grade index	: 2	: - .334 + .063
		: Uniformity ratio	: 3	: - .192* + .080
		: Fiber weight per inch	: 4	: - .181* + .098
		: Fiber strength	: 5	: + .143* + .069
		: Upper half mean length	: 6	: - .134* + .073
1 inch and 1-1/32 inches	: 304 :	: Fiber weight per inch	: 1	: - .354 + .077
		: Grade index	: 2	: - .182 + .056
		: Fiber strength	: 3	: + .105* + .056
		: Uniformity ratio	: 4	: - .033* + .059
		: Upper half mean length	: 5	: + .018* + .062
		: Percentage of mature fibers	: 6	: + .012* + .064
1-1/16 inches and 1-3/32 inches	: 240 :	: Fiber weight per inch	: 1	: - .328 + .088
		: Grade index	: 2	: - .161* + .062
		: Percentage of mature fibers	: 3	: - .065* + .075
		: Fiber strength	: 4	: + .025* + .065
		: Uniformity ratio	: 5	: + .022* + .066
		: Upper half mean length	: 6	: + .014* + .070
31/32 inch, 1 inch, and 1-1/32 inches	: 365 :	: Fiber weight per inch	: 1	: - .335 + .071
		: Grade index	: 2	: - .205 + .049
		: Fiber strength	: 3	: + .086* + .051
		: Percentage of mature fibers	: 4	: - .053* + .057
		: Upper half mean length	: 5	: + .043* + .056
		: Uniformity ratio	: 6	: - .023* + .055

^{1/} The sign indicates the direction of the contribution of the fiber property to nep count.

* Statistically insignificant, being less than 3 times its standard error.

Table 9.— Relative gross importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by series and year, crop years 1945-47

Groups of cotton according to —	Cottons	Fiber property	Rank	Simple correlation coefficient $\frac{1}{\bar{r}}$		
				\bar{r}		\bar{r}^2
	Number					
Over-all, 1945-47	828	Fiber weight per inch	1	-0.454	+ 0.028	0.206
		Upper half mean length	2	+ .336	+ .031	.113
		Uniformity ratio	3	- .333	+ .031	.111
		Percentage of mature fibers	4	- .303	+ .032	.092
		Grade index	5	- .201	+ .033	.041
		Fiber strength	6	+ .152	+ .034	.023
Selected cotton improvement groups, 1946, 1st picking	78	Fiber weight per inch	1	- .607	+ .072	.369
		Percentage of mature fibers	2	- .389	+ .097	.151
		Uniformity ratio	3	- .336	+ .101	.113
		Upper half mean length	4	+ .296*	+ .104	.088
		Fiber strength	5	- .195*	+ .110	.038
		Grade index	6	.000	—	**
Selected cotton improvement groups, 1947, 1st picking	86	Fiber weight per inch	1	- .544	+ .076	.296
		Percentage of mature fibers	2	- .434	+ .088	.189
		Upper half mean length	3	+ .411	+ .090	.169
		Fiber strength	4	- .206*	+ .104	.042
		Grade index	5	- .161*	+ .106	.026
		Uniformity ratio	6	.000	—	**
Selected cotton improvement groups, 1947, 2d picking	80	Percentage of mature fibers	1	- .587	+ .074	.345
		Fiber weight per inch	2	- .516	+ .083	.266
		Fiber strength	3	- .343	+ .099	.117
		Uniformity ratio	4	- .338	+ .100	.114
		Upper half mean length	5	+ .332	+ .100	.110
		Grade index	6	- .180*	+ .109	.032
Selected cotton improvement groups, 1947, 1st and 2d pickings	166	Fiber weight per inch	1	- .531	+ .056	.282
		Percentage of mature fibers	2	- .512	+ .057	.262
		Upper half mean length	3	+ .383	+ .066	.147
		Fiber strength	4	- .283	+ .072	.080
		Uniformity ratio	5	- .196*	+ .075	.039
		Grade index	6	- .182*	+ .075	.033

See footnotes at end of table.

Table 9.-- Relative gross importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by series and year, crop years 1945-47 --- Continued

Groups of cotton according to --	Cottons	Fiber properties	Rank	Simple correlation coefficient $\frac{1}{r}$	
				\bar{r}	\bar{r}^2
	Number				
Experiment Station:	210	Grade index	1	-0.405 + 0.058	0.164
Annual Variety		Uniformity ratio	2	- .370 +	.137
Series, 1945		Fiber weight per inch	3	- .352 +	.124
		Fiber strength	4	+ .291 +	.084
		Percentage of mature fibers	5	- .161* +	.026
		Upper half mean length	6	.000 ---	**
Experiment Station:	257	Uniformity ratio	1	- .563 +	.317
Annual Variety		Fiber weight per inch	2	- .563 +	.317
Series, 1946		Percentage of mature fibers	3	- .388 +	.150
		Upper half mean length	4	+ .353 +	.124
		Fiber strength	5	+ .271 +	.074
		Grade index	6	- .202 +	.041
Experiment Station:	117	Grade index	1	- .540 +	.291
Annual Variety		Upper half mean length	2	+ .515 +	.266
Series, 1947		Fiber weight per inch	3	- .479 +	.229
		Percentage of mature fibers	4	- .339 +	.115
		Uniformity ratio	5	- .305 +	.093
		Fiber strength	6	+ .166* +	.028

$\frac{1}{r}$ The sign indicates the direction of the contribution of the fiber property to nep count.

* Statistically insignificant, being less than 3 times its standard error.

** Imaginary (corrected \bar{r}^2 found to have a negative value).

Table 10.-- Relative gross importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by variety, crop years 1945-47

Variety	Cottons	Fiber properties	Rank	Simple correlation coefficient 1/ \bar{r} : \bar{r}^2		
	Number					
Coker 100 (all strains)	101	Grade index	1	-0.437 + 0.081	0.191	
		Percentage of mature fibers	2	-.182* + .097	.033	
		Uniformity ratio	3	-.119* + .099	.014	
		Upper half mean length	4	-.114* + .099	.013	
		Fiber weight per inch	5	.000 ---	**	
		Fiber strength	6	.000 ---	**	
Stoneville 2B	61	Percentage of mature fibers	1	-.414 + .107	.171	
		Fiber weight per inch	2	-.371 + .111	.138	
		Grade index	3	-.361 + .112	.131	
		Uniformity ratio	4	-.217* + .123	.047	
		Fiber strength	5	+.142* + .127	.020	
		Upper half mean length	6	.000 ---	**	
Deltapine 14	124	Grade index	1	-.425 + .074	.180	
		Percentage of mature fibers	2	-.292 + .082	.085	
		Fiber weight per inch	3	-.286 + .083	.082	
		Fiber strength	4	+.070* + .090	.005	
		Upper half mean length	5	-.054* + .090	.003	
		Uniformity ratio	6	-.036* + .090	.001	
Rowden (all strains)	46	Fiber weight per inch	1	-.385 + .127	.149	
		Percentage of mature fibers	2	-.379* + .128	.144	
		Uniformity ratio	3	-.323* + .134	.104	
		Grade index	4	.000 ---	**	
		Upper half mean length	5	.000 ---	**	
		Fiber strength	6	.000 ---	**	
Acala 1517, 1517W, W-29, 2815	50	Upper half mean length	1	-.318* + .128	.101	
		Fiber weight per inch	2	-.227* + .135	.052	
		Uniformity ratio	3	-.181* + .138	.033	
		Grade index	4	-.110* + .141	.012	
		Percentage of mature fibers	5	.000 ---	**	
		Fiber strength	6	.000 ---	**	

1/ The sign indicates the direction of the contribution of the fiber property to nep count.

* Statistically insignificant, being less than 3 times its standard error.

** Imaginary (corrected \bar{r}^2 found to have a negative value).

Table 11.—Relative gross importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by staple length, crop years 1945-47

Staple length	Cottons	Fiber properties	Rank	Simple correlation coefficient $\frac{1}{r}$		
				\bar{r}	\bar{r}^2	
	Number					
7/8 inch	37	Uniformity ratio	1	-0.595	+ 0.108	0.354
		Fiber weight per inch	2	-.379*	+ .143	.144
		Percentage of mature fibers	3	-.276*	+ .154	.076
		Fiber strength	4	.000	---	**
		Upper half mean length	5	.000	---	**
		Grade index	6	.000	---	**
29/32 inch	32	Uniformity ratio	1	-.527	+ .130	.278
		Fiber weight per inch	2	-.486	+ .137	.236
		Percentage of mature fibers	3	-.472	+ .140	.223
		Grade index	4	-.376*	+ .154	.142
		Fiber strength	5	.000	---	**
		Upper half mean length	6	.000	---	**
15/16 inch	90	Uniformity ratio	1	-.560	+ .073	.314
		Fiber weight per inch	2	-.518	+ .028	.269
		Percentage of mature fibers	3	-.506	+ .079	.256
		Grade index	4	-.286*	+ .097	.082
		Fiber strength	5	.000	---	**
		Upper half mean length	6	.000	---	**
31/32 inch	61	Percentage of mature fibers	1	-.566	+ .088	.320
		Fiber weight per inch	2	-.532	+ .092	.284
		Uniformity ratio	3	-.531	+ .093	.282
		Grade index	4	-.246*	+ .121	.061
		Fiber strength	5	.000	---	**
		Upper half mean length	6	.000	---	**
1 inch	116	Uniformity ratio	1	-.436	+ .076	.190
		Grade index	2	-.403	+ .078	.163
		Fiber weight per inch	3	-.373	+ .080	.139
		Percentage of mature fibers	4	-.236*	+ .088	.056
		Fiber strength	5	+.156*	+ .091	.024
		Upper half mean length	6	-.120*	+ .092	.014

See footnotes at end of table.

Table 11.-- Relative gross importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by staple length, crop years 1945-47

Staple length	Cottons	Fiber properties	Rank	Simple correlation coefficient		1/ \bar{r}^2
				\bar{r}		
	Number					
1-1/32 inches	188	Fiber weight per inch	1	-0.444 +	0.059	0.197
		Grade index	2	-.200* +	.070	.040
		Fiber strength	3	+.197* +	.070	.039
		Uniformity ratio	4	-.174* +	.071	.030
		Percentage of mature fibers	5	-.151* +	.071	.023
		Upper half mean length	6	+.145* +	.072	.021
1-1/16 inches	160	Fiber weight per inch	1	-.364 +	.069	.132
		Grade index	2	-.294 +	.072	.086
		Percentage of mature fibers	3	-.240 +	.075	.058
		Uniformity ratio	4	-.068* +	.079	.005
		Upper half mean length	5	+.045* +	.079	.002
		Fiber strength	6	.000	---	**
1-3/32 inches	80	Fiber weight per inch	1	-.444 +	.090	.197
		Fiber strength	2	+.340 +	.100	.116
		Percentage of mature fibers	3	-.198* +	.108	.039
		Uniformity ratio	4	-.160* +	.110	.026
		Upper half mean length	5	+.124* +	.111	.015
		Grade index	6	.000	---	**

^{1/} The sign indicates the direction of the contribution of the fiber property to nep count.

* Statistically insignificant, being less than 3 times its standard error.

** Imaginary (corrected \bar{r}^2 found to have a negative value).

Table 12.-- Relative gross importance of the respective fiber properties to number of neps per 100 square inches of processed card web, by combination of staple lengths, crop years 1945-47

Combination of staple lengths	Cottons	Fiber properties	Rank	Simple correlation coefficient $\frac{1}{\bar{r}}$			\bar{r}^2
	Number						
7/8 inch and 29/32 inch	69	Uniformity ratio	1	-0.544	+ 0.085		0.296
		Fiber weight per inch	2	-.452	+ .096		.204
		Percentage of mature fibers	3	-.378	+ .104		.143
		Grade index	4	-.226*	+ .115		.051
		Upper half mean length	5	+.046*	+ .121		.002
		Fiber strength	6	.000	---		**
15/16 inch and 31/32 inch	151	Percentage of mature fibers	1	-.511	+ .060		.261
		Uniformity ratio	2	-.476	+ .063		.226
		Fiber weight per inch	3	-.458	+ .065		.209
		Grade index	4	-.343	+ .072		.118
		Fiber strength	5	.000	---		**
		Upper half mean length	6	.000	---		**
1 inch and 1-1/32 inches	304	Fiber weight per inch	1	-.428	+ .049		.183
		Grade index	2	-.264	+ .053		.070
		Uniformity ratio	3	-.243	+ .054		.059
		Percentage of mature fibers	4	-.200	+ .055		.040
		Fiber strength	5	+.170	+ .056		.029
		Upper half mean length	6	+.082*	+ .057		.007
1-1/16 inches and 1-3/32 inches	240	Fiber weight per inch	1	-.386	+ .055		.149
		Percentage of mature fibers	2	-.234	+ .061		.055
		Grade index	3	-.214	+ .062		.046
		Uniformity ratio	4	-.124*	+ .064		.015
		Upper half mean length	5	+.093*	+ .064		.009
		Fiber strength	6	+.081*	+ .064		.007
31/32 inch, 1 inch, and 1-1/32 inches	365	Fiber weight per inch	1	-.450	+ .042		.202
		Grade index	2	-.288	+ .048		.083
		Percentage of mature fibers	3	-.268	+ .049		.072
		Uniformity ratio	4	-.246	+ .049		.061
		Upper half mean length	5	+.142*	+ .051		.020
		Fiber strength	6	+.087*	+ .052		.008

$\frac{1}{\bar{r}}$ The sign indicates the direction of the contribution of the fiber property to nep count.

* Statistically insignificant, being less than 3 times its standard error.

** Imaginary (corrected \bar{r}^2 found to have a negative value).